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OBSERVATIONS

ON THE

NATURE and THEORY

OF

V I S I O N:

WITH AN

INQUIRY

INTO THE

CAUSE OF THE SINGLE APPEARANCE

OF

OBJECTS SEEN BY BOTH EYES.

By JOHN CRISP, F. R. S.

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OBSERVATIONS
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OF THE

ON THE

NATURE AND THEORY

To Mr Jos. Banks. Bart. H. B.

from his most obedient and
most obliged servant,

J. B.

Jos. Banks

INTRODUCTORY PREFACE.

IT is probable that the human mind has never been subject to any illusion more general or more forcible, than that of conceiving the objects of sight to be external and remote, and to be perfectly distinct from the images which are known to be projected on the retina. Even persons of science, the latest and most esteemed writers on optics, in the accounts they give of the nature of vision, represent the projections on the retina as a set of images extremely minute and inverted with respect to the objects which are seen, and as only constituting a step in the process of vision, or as the mean by which the external object is rendered visible. The important discovery of the sagacious KEPLER, re-

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specting the seat of vision, left in full force a general persuasion that the objects of sight were distinct from the projections which he so fortunately brought to notice ; nor has the progress which of late years has been made in the general science of optics yet subdued this powerful and universal prejudice.

It may perhaps be said, that in the system of the human mind which generally prevails at this day, the immediate objects of perception are held to be ideas, and not the external material things themselves. But this philosophical notion of ideas does not respect visible objects alone ; it extends equally to those of every other sensitive faculty ; and in this philosophy the idea is supposed to have some external object for its archetype, with which it corresponds. And it clearly appears from their writings, that philosophers of this class conceive, that besides the various visible objects with which they are surrounded, there exists a distinct set of
minute

minute images projected on the retina :

Images of the things which they see.

A DOCTRINE the reverse of this is asserted in the following "OBSERVATIONS;" where it is maintained, that the projections on the retina are the immediate and sole objects of sight; that the visible buildings, fields, trees, and animals, which appear around us, are not a set of objects seen *by means* of the projections, but that they are the projections themselves. And in support of this position the Writer does not pretend to bring forward any one single fact or phenomenon that has in it the smallest degree of novelty; the proof of the assertion depending entirely on the circumstances which accompany even the most simple and ordinary phenomena of vision.

ON the misconception now noticed, is founded a question in vision, which has

much engaged the attention of optical writers; namely, “Why do objects appear erect when the images by which they are seen are inverted?” a question obviously implying that the thing seen is distinct from the image. And it is well worthy of remark, that another question, which has been, at least, equally agitated, namely, “Why do objects appear single when seen by both eyes?” is inconsistent with the former: there is in either of them an implication which does away the other. Thus: if, as the first implies, the external object is the thing seen, the second question drops; for, this being admitted, if any one should ask why objects are seen single with two eyes, the true answer would be simply this, *because they ARE single*; for the number of images by means of which an object may be seen, cannot affect the unity of that object when seen.

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ON the other hand, if, to give substance to the latter question, we admit the images to be the things seen, the first question vanishes, since it implies two sets of objects, of which the external is that seen: but if the image is the visible object, there is no longer any inversion, for the question allows this to be erect.

A PROPOSED new solution of the question respecting single vision, published some time since by Dr. Wells, in a little work entitled "AN ESSAY UPON SINGLE VISION WITH TWO EYES," having lately fallen into the Writer's hands, the perusal of it occasioned the following "OBSERVATIONS." The solution therein proposed to the Public did not appear to the Writer to be adequate; for, even admitting the facts respecting visible direction to be as stated by Dr. Wells, it would not thence necessarily follow, that objects appear single *in consequence* of such a law of visible direction.

THE projections of the optic axes on the retinae are single points, and the apparent union of these points, which is a well-known fact in vision, may be the consequence of some original property of the eyes, or of some primary law of the human constitution; and, as such, the original fact from whence the seeming *united direction* from the eye may be derived: and there would still arise this question: "Which is prior in the nature of things? the seeming unity of the *direction*, or the apparent union of the points?" or, "Which of the two circumstances is original, which is derived?"

BUT, independent of this consideration, certain facts may, as the Writer thinks, be produced in direct opposition to the propositions respecting visible direction laid down by Dr. Wells. These facts will be stated in the course of the following "OBSERVATIONS."

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THE solution of Dr. Wells, however, is ingeniously imagined and will probably meet the acquiescence of many: and in proportion to this assent, will be the degree of its tendency to put a stop to the farther investigation of the subject. On this account the Writer conceived, that to point out its defects might be of some service to the general cause of science, and tend to promote future research respecting a fact, which is not yet accounted for on just and adequate principles.

BUT when the Writer came to state his objections to the proposed solution, he perceived, that, in order to comprehend their force, it was requisite to entertain just notions of the true nature of vision in general, and in particular with respect to what has been noticed in the foregoing part of this Preface. This induced him to make some general previous observations on the subject; and a desire to be understood by those who may

not

not have been in the habit of considering the subject philosophically, has lain him under the necessity of repeating many things that have been said by other writers, and are well known to such as have made optics their study; and which therefore may, perhaps, to such, render the first Sections of the following "OBSERVATIONS" tedious and uninteresting. However, he trusts, that even in this part some few observations may be found interspersed, which are either in some degree new in themselves, or in the mode of their application. What is objected to the theory of Dr. Wells will be found in the Fourth and following Sections.

AFTER all, the Writer is very ready to confess, that the frequent occasions he has found in the course of his life to correct opinions, which he had supposed to be founded on the firmest principles, have induced a general diffidence, and rendered him but little tenacious of any doctrine whatever:

And if, on the present occasion, he shall be found in error, he will, as soon as it is pointed out to him, acknowledge it with as much readiness as he now proposes his opinion.

No. 5, Upper Fitzroy Street,

Feb. 10, 1796.

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ADVERTISEMENT.
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While this little work was in the press, the
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stances come to his knowledge before the first issue

* Appendix to Monthly Review (New Series) Vol. VII.
1799, Art. 13, p. 239.
printed

ADVERTISEMENT.

WHILE this little *Work* was in the press, the *Writer*, by mere accident, on looking over some volumes of the *Monthly Review**, became acquainted that a German work had been published by Mr. H. Aenæ, A. L. M. at Amsterdam, in which some circumstances are mentioned, and some observations made, respecting the erect appearance of objects seen by means of inverted images, very similar to what will be found in the following pages, and with a like intention of refuting the opinion of Dr. Reid on this subject. Of this work, the *Writer*, even now, knows nothing more than what is inserted in the *Review*. But had the circumstance come to his knowledge before the sheet was

* APPENDIX to *Monthly Review* (New Series) Vol. VII.
1792, Art. 13, P. 539.

printed off, he certainly would either have omitted what he has said, or would have differently modified it, with mention of the German work here noticed. As it is, nothing remains for him but to insert this Advertisement; and after all, such coincidences of opinion, where there has been no previous communication, are in themselves circumstances really worthy of notice, and generally form a strong presumptive proof of the validity of the reasoning.

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OBSERVATIONS,

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SECTION I.

General Observations.—The Difficulty of distinguishing Notions founded on Experience and an acquired Habit of judging, from simple and original Perceptions by Sight.—Examples. — The Process of Vision erroneously stated by optical Writers.

THE bulk of mankind are little aware of how complex a nature is the operation of vision, or how many powers of the mind

are concerned in the formation of those notions or perceptions which they are accustomed to consider as the simple operation of one sensitive faculty. The perception of visible extension, with its various modifications, of figure, position, and motion, necessarily results from the sensation of colour; but this sensation being merely an affection of the mind, or an effect produced upon it through the medium of the optic nerves, it follows, that we have no actual perception of external objects by sight; the notion of externality and remoteness, which we so constantly and uniformly annex to the objects we see, being founded on the habit of associating the perceptions of sight with those of touch, and is seated partly in the judgment and partly in the imagination.

ON this account the best optical writers have found it necessary to enter in some degree upon the philosophy of the human intellect, in order to explain the dependence which

which the ideas acquired by sight have on the other powers of the mind. But it is probable, that an unwillingness to mingle metaphysical speculation with demonstrative science may have prevented them from proceeding so far into this branch of knowledge as their subject really required; and hence I have had occasion to observe, even in some of the most esteemed writers on optics, such a looseness or inaccuracy of expression in explaining certain phenomena of vision, as must naturally tend to a want of precision in thought.

It is accuracy of distinction which constitutes the chief difference between the philosopher and the rest of mankind; and if we would reason justly concerning the various phenomena of vision, and expect to arrive at just solutions, we should never overlook the important distinction between the simple and original perceptions of sight, and those adscititious notions, which, notwithstanding

their uniformity throughout the species, are still the consequence of experience, and are properly to be referred to the judgment and imagination.

BUT the perception of sensible objects commencing at the earliest period of human existence, and the simple original perceptions being most intimately associated and confounded with those acquired notions whose origin is beyond the utmost stretch of memory, their separation in the mind which contemplates them becomes a matter of much difficulty. This distinction, totally disregarded by the generality of mankind, is sometimes overlooked even by the profest optical writer.

A FEW examples may serve to illustrate my meaning, and to relieve the reader.

THE seeming increase of apparent magnitude in the celestial bodies, for instance,

the moon when on or near the horizon, is a phænomenon which has been noticed by all optical writers. To the solution which has been given of this phænomenon by Dr. Smith I have nothing to add, nor any thing to object. But it is worthy of remark, that the habit of judging respecting the distance and magnitude of terrestrial objects extends to the celestial bodies, where the circumstances on which the principle of judgment is founded have no existence.

THOUGH the apparent magnitude of terrestrial objects is perpetually varying in proportion to their distance from the eye, still there is some sort of standard in the mind, perhaps indeed not very accurate, to which a reference is generally made. It is not possible to form a conception of a visible object, without some determinate magnitude, and this magnitude will in general be that which belongs to the object in that situation wherein we have been most accustomed to

view and consider it; the variations of apparent magnitude, the gradations of colour, and indistinctness of outline, which influence our judgment concerning the distance of terrestrial objects, are so many circumstances of real alteration in the visible object.

WHEN we see two men in a horizontal direction, one at the distance of ten, and the other at the distance of an hundred yards, there is a real diminution of apparent magnitude in the latter; but there being a regular succession of intermediate objects, all well known, and each appearing in due proportion to those with which it is contiguous, we pass over the diminished magnitude, attending only to the distance of which it is a sign. But if a man should be seen at the same distance in an elevated situation, as on the top of some high building, the mind not being accustomed to judge of distance in that direction, and there being no surrounding objects of known magnitude with
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which to compare it, and which might serve as a measure of proportion, the visible magnitude of the man becomes in this situation an object of attention, and appears diminished from being compared with that imperfect standard in the mind above noticed, and which is formed from the apparent magnitude of a man at a small distance.

AGAIN: when we look through a telescope, which magnifies the diameter of an object in a certain degree, we judge the object to appear nearer, but not larger; for, in this case, the visible magnitude, though really increased by the telescope, yet is not so increased as to exceed the magnitude which belongs to the object at distances in which we have been accustomed to view it. The increased magnitude corresponds with some one of those distances, and operates on the mind as a sign of it. But if the instrument magnified the object to a degree be-

yond any at which we had been accustomed to see it, or beyond the standard in the mind, we should then attend to the visible magnitude, and the object would appear not only as nearer but as larger. And this is what takes place when we look at an object through a microscope, when the visible magnitude being increased much beyond any standard to which the mind can refer it, or which corresponds with any distance at which we had been accustomed to see it, such increased visible magnitude engages the attention, and we view the object as magnified, without noticing the distance.

I HAVE only mentioned these circumstances, which are well known to those who have studied optics, in order to observe, that in such instances there is either some standard in the mind with which a visible object is compared, or some real alteration in the visible circumstances by which the judgment may be influenced. But in the phænomenon

non of the horizontal moon every thing remains the same, the true magnitude is unknown to sensible perception, and cannot be made a standard of comparison in the mind ; but this true magnitude remains unaltered. The visible magnitude, or the space the object occupies on the retina, also remains unchanged in all the various degrees of elevation, and the real distance remains the same, or at least the variations to which it is subject have no influence in the matter we are considering. And, lastly, we are as much accustomed to see the moon at an elevation as on the horizon.

Thus it appears, that the variable visible magnitude which takes place with respect to terrestrial objects, and which in conjunction with other circumstances becomes the sign of distance, can have no place with regard to the celestial object. And yet mankind invariably agree in thinking that the moon appears larger when on or near the horizon than

than when at an elevation ; and by appearing larger, they in general mean that it is a larger object to sight ; and the manner in which some optical writers express themselves on this subject rather seems to countenance than to correct such a notion ; but the philosopher knows that the increase of magnitude is neither real nor apparent : the visible object really undergoes no alteration of magnitude in any situation ; the angle subtended by the diameter, or the space occupied on the retina, is the same throughout all degrees of elevation ; and the seeming increase of the magnitude is truly the operation of a faculty very distinct from simple vision. However, so difficult is it to make this distinction, that the philosopher who is acquainted with the subject, equally with the uninformed part of mankind, while contemplating the moon upon the horizon, cannot avoid considering it as *appearing* of increased magnitude,

IN the foregoing instance a real distinction is overlooked. In the next instance I shall mention there is a distinction made where none really exists: this is, in seeing by reflection from a mirror,

WHEN any object is placed before a plane mirror, we see two similar things; one by direct rays, the other by rays reflected from the mirror. Now, mankind in general attribute to one of these visible objects a reality which they deny to the other; they consider the object which they see by the reflected rays, or, as they express it, "IN THE GLASS," as the image of *the other* which they see by direct rays; and the general mode of expression used by optical writers conforms to such a notion.

It is, however, certain, that the two visible objects seen in such a situation are perfectly similar in their nature, and the one seen by direct rays has no circumstance of externality



nality or reality belonging to it, which can with any reason be denied to the other. The rays which are reflected by the mirror do not issue *from the other object* which is SEEN direct, but this last is seen by rays which issue from the same source which sends the rays to the glass; and the identic rays which excite that appearance which we call the reflected image of the other might, if the glass were removed, pass on straight to some other eye, where they would form a visible object precisely similar in every circumstance to that seen without the mirror, and which is generally considered as the real or external object. The only difference then in the two objects is, that one is caused by rays which pass in a straight line to the eye, and the other by rays which, impinging on the mirror, are sent out of their straight course; but this circumstance can make no real difference in the nature of the object seen. Here then a very important distinction is made where none really exists; for one of these
objects

objects is considered as external and real, and the other as a mere appearance.

It is not to be supposed, that optical writers can be unacquainted with these circumstances, though it is very certain, that their general mode of expression conforms to the vulgar opinion. But, however allowable such a conformity may be in matters which relate to the ordinary intercourse of life, it ought not to be admitted in matters of science, where the particular province of the writer is, to correct the erroneous opinions of the uninstructed part of mankind: or, if it should be said, that the common expression of “an object and *its image*,” is used merely for the sake of distinction, this should be noticed, and the true nature of the objects explained.

BUT the notion which of all others is most intimately associated and confounded with the simple perceptions of sight, is that of
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externality and remoteness which we annex to every thing we see; and so strongly is this notion impressed on the minds of those who have not been accustomed to view the subject in a philosophical light, that the bare attempt to correct it renders one liable to the charge of absurdity, and of advancing positions repugnant to common sense.

AND here we may again observe, that the explanation given by most optical writers of the ordinary process of vision conforms in expression with the general opinion. We are told, that the rays of light which issue from every point of an external object falling on the eye are, by the laws of refraction, collected into certain corresponding points on the retina, where they form a picture of the object in an inverted position; which picture or image, through the action of the optic nerve, is the mean by which the external object becomes visible: that is, they conceive two distinct sets of objects; one, the
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external objects, which they represent as the things *seen*; the other, the inverted pictures of them on the retina, which are *not seen*.

AND it appears, from the manner in which these writers state some questions relating to the phænomena of vision, that they do not express themselves in this manner merely in conformity to general opinion, but that they really consider the thing seen as something very distinct from the projection on the retina. Thus a question which has given rise to much speculation on this subject is, On what principle is it to be accounted for, that objects are seen erect by means of inverted images? The question thus stated evidently implies, that the object seen is one thing, and the image on the retina another: and the ingenious Dr. Smith, who has treated the subject of vision fully, and in some degree philosophically, applied himself to calculate the

the magnitude of the picture on the retina of the smallest visible object; or of what he calls a sensible point on the retina, which he makes to be the eighth-thousandth part of an inch*. This is certainly supposing the picture on the retina to be somewhat distinct from, and inconceivably small in proportion to, the visible object.

BUT such an account of vision tends to mislead; for the truth is, that we have no perception whatever of external objects by sight, either mediate or immediate; the projections on the retina being the direct and sole objects of vision. And this position is advanced as a plain truth whose proof does not rest on any metaphysical subtlety, but which is capable of as full and clear a demonstration from the most simple and familiar phænomena of sight, as any proposition throughout the whole extent of natural

* Smith's Optics, Vol. I. p. 31.

philosophy. But, as a prejudice so general and so deep-rooted as is that of seeing external objects cannot easily be removed, I shall in the following Section state some general principles which, when well understood, will assist in forming just notions on this subject.

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SECTION II.

*An Exposition of certain general Principles
necessary to a right Understanding of the
true Nature of Vision. Fallacious Reason-
ing of Dr. Reid pointed out *.*

ONE proposition which we should ever have in view, if we would form just notions on the subject we are treating, is, that colour has no existence independent of the mind ; that it is no quality existing externally in material substance, but an effect produced on the mind by the action of the rays of light on the organs of vision ; all the variety of colours we see depending on the circumstances under which the rays act on the optic nerves.

* THE writer published some " Observations on Single Vision" in the European Magazine for September 1794, some of which are repeated in this Essay.

It would be superfluous to enter here at large, on the proof of a position so well known, and so generally admitted. I shall, however, introduce one experiment which, though simple, is perfectly decisive*.

It is a well-known fact, that if two substances perfectly dry and finely powdered, the one of a blue, the other of a yellow colour, should be mixed together, the mass would exhibit a green colour.

From this simple experiment arise the following observations: if the substance should have been from the first presented to us under this form, we should have considered it as

* THIS doctrine respecting colour has, however, lately been called in question by Dr. Reid, of Glasgow, and Dr. Beattie, of Aberdeen; but the fallacy of their reasoning on this subject might very easily be pointed out. And, indeed, what kind of philosophy can be expected from writers whose fundamental tenet is, "that popular persuasion or belief is the ultimate test of truth;" or "that we believe because we cannot help it, and that what we cannot help believing is true." See Dr. Reid's "Inquiry into the Mind on the Principles of common sense," and Dr. Beattie's Essay "On the Nature and Immutability of Truth."

being of a green colour, for the same reason that we now consider the two as being one yellow, the other blue, the green colour has equal claim to reality and to be considered as a quality of the substance, with the former; but in this instance the two substances remain the same after the mixture as before; the change which takes place does not affect their nature, but respects only the arrangement of their individual particles, and their mutual position in regard to each other, while every single particle remains separate and distinct; neither is there any alteration in the nature of the rays of light which enter the eye after the mixture of the substances: the same species of rays issue from the mass as before the union, and each ray enters the eye also separate and distinct. But in this situation the rays issuing from an individual particle of either substance do not occupy a sensible point on the retina, and therefore do not singly, excite any sensation, or become separately visible; but over such a sensible point are diffused rays which issue equally
both

both from the blue and the yellow particles ; and the consequence is, the sensation of a green colour ; a sensation excited by the combined action of two sorts of rays on one sensible point. But if the mass should be viewed through a lens of a proper degree of convexity, the rays issuing from an individual particle of either substance would in this case occupy a sensible point on the retina, and the blue and the yellow particles would be seen distinct from each other.

BUT these sensible points on the retina differ from geometrical points ; for the latter have no dimensions, and cannot be objects to sense ; but the former have dimensions, or they could not be perceptible ; and thus the sensation of colour, when excited, necessarily produces the perception of visible extension, which is composed of such sensible points. The extension is included in the nature of colour, since the two are absolutely inseparable in the imagination. It is impossible to conceive colour distinct from length and breadth, or

to conceive visible extension unaccompanied with colour ; but extension in its nature consists of parts, each of which has a certain position in respect to every other part. Position is pointed out by a difference of colour, which gives limits to certain portions of extension, and extension circumscribed constitutes figure. Again : a continued successive change of position constitutes motion ; and thus the perception of visible extension, with its various modifications, of figure, position, and motion, results from the sensation of colour.

IT is usual for optical writers to speak of the rays of light, as being continuous lines, and this may be commodious for the purpose of optical demonstration ; but we know that it is not absolutely just. A ray of light consists of extremely minute particles issuing from a body in the same direction, but perfectly distinct, and at very considerable distances from each other. The rarity of light, considered as a medium, has been particularly noticed

noticed by the ingenious Mr. Melville and others; and it is supposed that one individual particle may have proceeded to the distance of some thousands of miles before another particle quits the body in the same direction; but so considerable is the velocity of their motion, that the interval in time is utterly imperceptible to sense.

If we should conceive rays of light as continuous lines extending from an object to the eye, it might seem to form a sort of connection between the two, and might tend to strengthen the erroneous notion of seeing the external thing: but if we consider that the particles of light which strike the eye and excite the sensation of colour, are absolutely detached from the object, and that it is even possible that an object may no longer exist, when that light which causes what we call the sight of it reaches the eye, we shall certainly be better prepared to admit the doctrine which I have advanced.

IN every instance where an object is presented to the mind by means of sight, it will probably be found, that judgment and imagination are concerned together with actual perception. And the true nature of vision can never be rightly comprehended without making a proper distinction between these various operations. But to this end it is requisite that we should entertain just notions of the general nature of perception, as distinguished from the other powers of the mind; for the great latitude and variety of signification with which this term has been used by different writers is utterly inconsistent with any idea of perspicuity.

It is not easy to define simple operations of the mind, but I should explain my notion of perception by saying, that it is an effect produced on the mind, in which some object is *immediately present* to notice or apprehension.

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IN perception the object is actually present to the mind ; knowledge may be considered as consisting of former perceptions repositied in the memory. Thus, I know that the three angles of every plane triangle are, when taken together, equal to one hundred and eighty degrees, but when I am not thinking of triangles and their properties, I cannot be said to perceive this truth. It is then only it can properly be said to be perceived, when the whole demonstration lies before the mind, and every link in the chain of reasoning becomes an object of actual perception.

AGAIN : the object of perception must be *immediately* before the mind, and this is what constitutes the difference between perception and judgment : the latter being a certain degree of persuasion or assent of the mind respecting that, which is not perceived, through the mediation or intervention of some evidence, or an inference from existence perceived, to existence unperceived. But the object of perception being actually present to
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the mind, it must in consequence necessarily exist, and thus perception implying existence is the basis of all certainty * ; nor can there be any false or erroneous perception, for it is equally contradictory that what is perceived should not exist, or that what has no existence should be perceived : and all those first principles of science which are called axioms, are only so many simple actual perceptions expressed in general terms for the purpose of communication.

THE seat of error is the judgment, or that faculty by which the mind forms conclusions respecting unperceived existence, and all those illusions which are frequently termed fallacies of the senses, are, properly speaking, erroneous judgments or false conclusions, for the senses present their objects to the mind agreeably to certain regular stated laws of nature, and therefore without fallacy ; the er-

* I AM here speaking of existence in general, not meaning to limit the signification of the term to permanent existence independent of the mind.

ror lying in the inferences which the mind draws from the objects presented by one sensitive faculty, respecting the existence of those of another faculty: as, when seeing an object of a certain colour and figure, we conclude it to be an orange, but, on examination, find it to be a piece of wax or painted wood: or, as when a stick is seen with part of it lying in water; in this case the visible appearance is certainly crooked, and so it ought to be by the laws of vision; but if one should thence conclude that the same stick would really be crooked when out of the water, we should form an erroneous judgment, while the appearance would be just and regular.

WHEN a sphere is placed before the eyes we see only a circular figure, over which is diffused a certain gradation of colour, or of light and shade; the sphericity or solidity is a conception or notion formed within the mind and associated with the actual perception. But this circular figure and gradation

of colour, which, from experience, excite the conception and belief of sphericity, neither constitute it nor have any necessary connection with it; for a plane circular surface may be so coloured as to exhibit to the eye precisely that gradation of colour which is the usual sign of sphericity; and if a sphere and a plane circular surface so coloured should be at the same time placed before the eyes, we should have no criterion whereby to distinguish the plane from the solid. Suppose then the eyes to be directed to the plane surface: in this situation the object, so far as mere sight is concerned, would be precisely the same as if the eyes were directed to the solid; but, since a solid cannot be perceived where no such thing exists, it necessarily follows, that solidity or the third dimension, is not perceptible by sight; but that externality and remoteness, the notion of which we so uniformly annex to the objects we see, is no other than this third dimension: and hence it also follows, that distance in a line from the eye is no direct object of sight.

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If there does exist a set of external objects, and if the mind is endowed with a power of perceiving these objects, it must perceive them such as they are; the nature of the organs of sense or the mode by which the perception is conveyed to the mind can make no difference in the nature of the object when perceived. We frequently hear mention of apparent figure and of apparent magnitude, as qualities or attributes of things, which have at the same time a different real figure or real magnitude; but this is a very inaccurate and unphilosophical manner of speaking, for no principle can be more obvious than this, that one individual thing cannot have two different figures or different magnitudes at the same time. Every thing whatever possesses certain qualities which distinguish it from every other thing, which constitute its essence or cause it to be what it is. It is impossible that a thing should differ from itself or possess at the same time qualities repugnant to each other. And therefore, if the external things have certain properties, and if the things perceived have other properties different from those

those or inconsistent with them, it must follow, that the things perceived are not the external things. No reasoning can be more plain and simple than this. If it should be said that we perceive part of an object by one faculty and part by another, it may be replied that the objects of different faculties are, in truth, different things ; we possess no faculty competent to the perception of substance or the substratum of qualities and the principle of individuality is a meer work of the mind. It is impossible that a hard or soft thing ; a rough or a smooth thing should be seen, or that a red, a blue, or a yellow thing should be felt.

EXTENDED figured objects are susceptible of various relations among themselves which are no relations with regard to the percipient ; such are those of place and position. While any object preserves its identity, it must if perceived, be perceived to be the same whatever may be its situation ; for if this circumstance causes no real alteration in the nature, magnitude or figure of the object, neither can it

it cause any in the perception of that object. Mind or a percipient principle has not itself any immediate relation to space ; for if it existed in place or occupied space, it must be extended and figured *. We may suppose a cube and

* THERE are, I know, many, and some even who are in habits of abstract study, who find a difficulty in conceiving, that any thing whatever can exist without place, or who suppose that the question "Where is it?" is applicable to every thing whatever. And, indeed, the notions of space and extension are so deeply impressed on the minds of those who are possessed of the faculties of sight and touch, and the imagination is so much more constantly employed on the objects of these faculties than on those of the rest, as to render it a matter of difficulty to divest the mind of these notions. We need not enter on a full discussion of this question here, but the following considerations may perhaps assist our conceptions on this subject.

Of the five sensitive faculties there are three, namely, taste, smell, and hearing, whose objects have no relation to space, and which therefore could not convey to the mind a notion of extension or its modes. A sound, for instance, may be grave or acute, of long or short duration, harmonious or discordant, &c. but it would be obviously absurd to speak of a sound that had length, or breadth, or figure.

If we should, then, suppose a being endowed with only these three sensitive faculties, but to possess the same intellectual powers as man, such as reason, memory, and imagination: it is evident that such a being could have no notion of space or extension; but the variety of other notions which might arise from these faculties is considerable, such as duration, with its modes of succession, prior and posterior, &c. He might also acquire a notion of numbers, of similarity, diversity,

and a sphere to be placed in a variety of situations, one with respect to the other, but it would be obviously absurd to consider these circumstances as relations in regard to the percipient. If, for instance, the cube were to be removed to a distance from the sphere, with what propriety could it be said to be removed at the same time to a distance from the mind; or that the cube lay on one side of the mind and the cube on the other?

sphere

I SHALL conclude this section with some observations on a remarkable instance of false reasoning in an eminent writer,* in great

sity, equality, and many others; and we should find that such a being might have notions which come under seven of the ten categories, and consequently there would be room for much exercise of reason and imagination, without any notion of extension and its modes. This may be sufficient to shew, that the idea of space is not a necessary idea in the mind of an intellectual being. The notion arises from the nature of the sensitive faculties, but there may exist beings of intellectual powers and faculties far exceeding those of the human species, who, notwithstanding, may be without those faculties to which the perception of space and extension is appropriated, and who may, therefore, be destitute of such notions.

* DR. Thomas Reid, Professor of Moral Philosophy in the University of Glasgow, in a work entitled, "Essays on the Intellectual Powers of Man." See this Work, from Page 206 to 212.

measure

measure founded on considering the relations which subsist among extended things, as being also relations in respect to the percipient.

I SHALL produce the passage, not only as it has an immediate relation to the subject of these observations, but because it may be considered as a curious fact in the history of the human mind, and proves how readily an enlightened and strong understanding may be perverted by a predilection for some favorite theory.

THE grand aim of this writer throughout his works is, to abolish the received system concerning ideas; in opposition to which he maintains, that the mind is endowed with a power of perceiving external objects *immediately*; sensation being, in this writer's theory, only a sign passing rapidly and almost imperceptibly through the mind, suggesting, by some law of nature hitherto

unnoticed by philosophers; the immediate perception of the external object.

MR. Hume, somewhere in his writings, speaking of the general notion of the externality of the objects we perceive, says:

“ But this universal and primary opinion
 “ of all men is destroyed by the slightest
 “ philosophy, which teaches us, that no-
 “ thing can ever be present to the mind but
 “ an image of perception, and that the senses
 “ are the only inlets through which these
 “ images are received, without being ever
 “ able to produce any immediate intercourse
 “ between the mind and the object. *The*
 “ *table which we see seems to diminish as we*
 “ *remove farther from it; but the real ta-*
 “ *ble, which exists independent of us, suffers*
 “ *no alteration. It was, therefore, nothing*
 “ *but its image which was present to the*
 “ *mind.* These are the obvious dictates of
 “ reason;” — — — — So far Mr. Hume.

THIS

THIS passage is quoted by Dr. Reid in his *Essays on the Intellectual Powers of Man*, and his reply to it is the instance of false reasoning to which I have alluded. This writer, after having explained the difference between tangible and visible magnitude, proceeds thus:

“THE argument is this: ‘the table we see seems to diminish as we remove farther from it;’ that is; its apparent magnitude is diminished, ‘but the real table suffers no real alteration;’ to wit, in its magnitude; ‘therefore, it is not the real table we see.’ I admit both the premises in this syllogism, but I deny the conclusion. ‘The syllogism has what the logicians call two middle terms; apparent magnitude is the middle term in the first premise, real magnitude in the second. Therefore, according to the rules of logic, the conclusion is not justly drawn from the premises. But, laying aside the rules of
D 2 “ logic,

“ logic, let us examine it by the light of
 “ common sense.

“ LET us suppose, for a moment, that it
 “ is the real table we see; must not this
 “ real table seem to diminish as we remove
 “ farther from it? It is demonstrable that
 “ it must. How then can this apparent di-
 “ minution be an argument that it is not
 “ the real table? When that which must
 “ happen to the real table as we remove
 “ farther from it does actually happen to
 “ the table we see, it is absurd to conclude
 “ from this, that it is not the real table we
 “ see. It is evident, therefore, that this in-
 “ genious author has imposed upon himself
 “ by confounding real magnitude with ap-
 “ parent magnitude, and that his argument
 “ is a mere SOPHISM.

“ I OBSERVED, that Mr. Hume's argu-
 “ ment not only has no strength to support
 “ his conclusion, but that it leads to the
 “ contrary

“ contrary conclusion ; to wit, that it is the
 “ real table we see ; for this plain reason,
 “ that the table we see has precisely that
 “ apparent magnitude which it is demon-
 “ strable the real table must have when
 “ placed at that distance.”

SUCH is Dr. Reid's reasoning in opposition to Mr. Hume's syllogism ; in which it is surely the former who has imposed upon himself, and the sophism may be fairly retorted upon him.

THAT a person, endowed with talents so respectable as are those of Dr. Reid, should suffer himself to be deluded by so obvious and palpable a fallacy is indeed a memorable instance of the weakness of human reason. The whole train of argument here adduced ; this supposed detection of a sophism in the plain and simple proposition of Mr. Hume, does itself consist of a string of sophisms and erroneous notions from beginning to end.

FIRST : the author conceives the distance of the table to be a relation with respect to the percipient ; he supposes it to be carried away from the mind when it is removed to a distance from the body ; a mere prejudice of untutored minds, but a notion very unworthy of one accustomed to view subjects in the light of philosophy. While an object remains unchanged in its own nature, the perception of that object, if the mind really has the power of perceiving it, must also remain unchanged.

In the next place, there is an obvious fallacy running through the whole argument, implying the existence of the very thing it denies ; that is, of a visible object distinct from the real or external object, and subject to certain laws of variation utterly inconsistent with the nature of the latter.

AGAIN : the author seems to be led away by the mere ordinary construction of language, considering the term apparent as a
 quality

quality or accident of which magnitude is the subject ; but this term, though predicated of magnitude, obviously relates to the percipient. Magnitude is only susceptible of more or less, and the external table, with all its attributes, remains precisely the same, whether it be apparent or not apparent.

WHAT Dr. Reid calls the two middle terms, real or fixed magnitude, and apparent or variable magnitude, are inconsistent qualities which cannot exist at the same time in the same subject. Dr. Berkeley, from whom Dr. Reid seems to have taken up his notions of visible and tangible magnitude, plainly perceived this, and he consequently maintains that there is no common object of sight and of touch. But Dr. Reid, allowing the premises and rejecting the conclusion, admits the absurdity that the same body may have at the same time two different magnitudes. Mr. Hume's argument may be stated thus :

The external table has a determinate, in-
variable magnitude;

The object seen has a variable magni-
tude;

But these two qualities cannot subsist at
the same time in the same subject:

Therefore, the external table is not the
object seen.

I CANNOT conceive sounder logic than
this is; and the sophistry is to be found in
Dr. Reid's reasoning, which attributes to the
same subject repugnant and inconsistent qua-
lities.

THE author says, "If we suppose, for a
moment, that it is the real table we see,
" it is demonstrable that it must seem to
" diminish as we remove farther from it,"
&c.

I COULD wish the writer had attempted
this demonstration of which he speaks; the
event

event might have led him to a perception of his error. While we remove to various distances, the table certainly remains precisely the same; neither it nor any of its attributes suffer any alteration, whether it be seen or not seen. The seeming diminution is not any affection of the external table, but of the projection on the retina; and though it may be demonstrated, that the angles made by lines drawn from a point to the extremities of a figure, must diminish, as the figure is farther removed from the point from which the lines are drawn; yet this is not by any means a demonstration that a mind endowed with the power of perceiving external objects which have a fixed magnitude, must perceive these objects as having a magnitude proportionate to such angles.

THIS may constitute a law of *vision* in beings framed as we are, but it can be no law of general percipiency; on the contrary it leads directly to this conclusion, that the faculty

culty of sight is not a power of perceiving external material objects ; since objects perceived by vision have, in consequence of this law, certain qualities and are subject to accidents, which cannot be predicated of external objects existing independent of the mind.

AGAIN : the writer says, "when that which must happen to the real table as we remove farther from it does actually happen to the table we see, it is absurd to conclude from this, that it is not the real table we see." But I would ask of Dr. Reid, what in this case does happen to the real table by our being farther removed from it? Surely nothing at all. The diminution which Dr. Reid calls seeming, is not seeming, but real ; it is no affection of the real table, which remains the same in all circumstances of distance ; but it is a real diminution of the projection or visible object, and which this writer throughout confounds with the external object.

UPON

UPON the whole, then, it appears, that Mr. Hume's syllogism is a simple and evident truth, founded on this obvious proposition, that a variable and an invariable magnitude cannot be qualities of the same subject at the same time; and the charge of sophistry fairly returns on Dr. Reid. But even the errors of such a writer afford a lesson to the wisest; they may hence learn to propose their opinions to the world with moderation and diffidence, lest a supposed detection of the errors of others may ultimately appear to be only an exposure of their own.

I HAVE dwelt at some length on this circumstance, because it is precisely a case in point, and tends to elucidate the subject we are considering.

It may be, however, necessary to observe here, that the theory which Dr. Reid intended to overthrow by the above reasoning, is somewhat very distinct from what has been

been advanced respecting the projections on the retina. The system he opposed is that which maintains that the immediate objects of human perception are ideas. The philosophers who embrace this doctrine may be distinguished into two classes: the first, and much the more numerous, at the head of which we may place Mr. Locke, admit the existence of the external or material object, which they consider as the archetype with which the idea has a general conformity; and it is evident from the writings of this class, (among whom was Dr. Smith, who has treated so largely on optics) that they in general consider the projections on the retina as being very distinct from the immediate objects of sight, and as constituting only a step in the process of vision.

THE other class deny altogether the existence of external objects, or of material substance; at the head of these we may consider

sider Dr. Berkeley and Mr. Hume, whose system has met with but few followers.

The general principles which have been stated in the preceding part of this Section may, I hope, in some degree, assist in forming a just conception of the subject to be treated; but I am sensible there are still some strong prejudices to be subdued.

It is evident from the writings of this class (among whom was Dr. Smith, who has treated so largely on optics) that they in general consider the projections on the retina as being very distinct from the immediate objects of sight, and as constituting only a step in the process of vision.

The other class deny altogether the existence of external objects, or of material substance; at the head of these we may consider

SECTION

SECTION III.

The Projections on the Retina the immediate Objects of Vision; no identic Objects of Sight and Touch. — Simple Experiments brought to prove the first Position. — The Question of seeing Objects erect by inverted Images considered.*

I AM well aware that the account I am about to give of the process of vision may

* To the reader, who is acquainted with what has been written on the subject of vision, it will readily occur that the principles advanced in the subsequent account nearly concur with those of the ingenious Dr. Berkeley as laid down in his "New Theory of Vision." However the writer of these observations had formed his notions on this subject from his own reflections long before the works of that celebrated author had fallen into his hands, and while residing in a very obscure and remote

at first subject me to the charge of advancing paradoxes, or notions repugnant to common sense, from those who are not in the habit of considering the subject in a philosophical light. However, I have little doubt, that a patient attention to what will be produced in support of the doctrine I shall state, will get the better of a prejudice deeply impressed on the mind, from a long continued habit of conceiving the object of sight to be external and remote.

I HAVE already stated in the First Section the manner in which the process of vision is generally explained by optical writers; in opposition to which, I have advanced, that we have not by sight any perception of external objects, and that the projections on the retina are the immediate and sole remote part of the world, when he could have but a very limited access to books and not any to the conversation and society of men of science and literature.

objects

objects of vision; but I shall state this position at more length.

It has already been observed, and I suppose at this time it is in general well understood, that colour is nothing more than an effect produced upon the mind through the medium of the organs of vision. The rays of light collected on the retina by their natural action on the optic nerve excite the sensation of colour, with the consequent perception of extension; and certain portions of this extension being limited and marked out by a difference of colour give rise to the perception of visible figure; thus the sensation of colour renders perceptible to the mind the figures projected on the retina: and this process constitutes vision.

We remain in total ignorance of the real efficiency of the rays of light on the optic nerves

nerves and the brain in causing vision; but when sight is produced, there is an object immediately present to the mind; and the present question is, not how this object is produced? But, what is it? Should any one chuse to maintain, that what I call the projections on the retina are only ideas, I do not feel inclined to dispute the point; however, we have the same evidence for the existence of these projections, as we have for those made on paper by a lens. If the things we see are only ideas, are they the ideas of external objects, or ideas of the projections on the retina? If they are more than ideas, are they the objects themselves, or are they the projections? The general opinion is, that the projections on the retina merely constitute a step in the process of vision, and are only the means by which the objects we see, whether these be the external things themselves, or only the ideas of them, become visible. That such is the opinion of optical writers appears from the

circumstances mentioned in the first section; and I appeal to the experience of every individual, let him be skilled in optics or not, Whether, whilst he contemplates the set of visible objects before him, consisting of buildings, fields, trees, animals, &c. and passes his eye over parts of his own person, he does not conceive that there is, besides these, a set of objects projected on the retina of his own eyes, in an inverted order, inconceivably minute, and perfectly distinct from the things which he sees?

I AM ready to confess for my own part, that even now, while writing expressly against such a notion, as I sit in my room, and view the various objects around me, I can scarcely avoid considering them as being distinct from the projections which we know are formed on the retina. I am apt to conceive of my own eyes as being those objects which I have seen by reflection from a mirror, and that these visible eyes are the
places

places where the projections are formed. And it is in opposition to a persuasion so general that I advance, that this set of objects which we see, these buildings, fields, trees, animals, &c. which we conceive to be external in regard to ourselves, are really no other than the projections on the retinae of our own eyes.

IN advancing this position the writer does not pretend to have discovered any new fact in vision; nor does the proof of this doctrine rest on any abstract subtlety, or metaphysical refinement whatever; but on this plain consideration, that the phænomena of vision are utterly inconsistent with the fact of seeing external objects; but are all perfectly conformable with the projections on the retina. Some very simple and common phænomena will be selected to illustrate this doctrine.

But before we proceed let me observe, that the scientific or geometrical part of optics will remain entirely unaffected by the position now advanced. The general properties of light, the laws of its refraction, reflection, inflection, &c. will all remain as before. What is called the external object, from which the rays of light are supposed to be reflected, these reflected rays, and the image they form, are equally supposed in either theory. The difference lies only in this circumstance, that the former doctrine teaches that the external object is the thing seen, and that the picture on the retina is only the mean by which it becomes visible; whereas I hold, that the external object is only tangible, and that the image or projection of this tangible object is what in the process of vision becomes visible.

It is the province of optics to unfold and to explain the various relations which these visible perceptions have to the external or tangible

tangible object, and to investigate and define the laws by which they are excited, and the changes they undergo from the various circumstances of light and situation. The direction in which light acts, the laws by which this direction is changed, with the consequent changes produced in the visible figures, are the chief objects of this science: all of which will remain unaffected by the position in question. And it is worthy of remark, that the science of optics is chiefly founded on notions originally derived from the sense of touch. Solidity, resistance, density or rarity of a medium, refraction, reflection, &c. are all tangible notions; and of two persons of whom one is supposed to possess the faculty of sight without that of touch, and the other that of touch without sight, there can be no doubt that the blind person might make a much greater progress in comprehending the principles of optics, than the one who possessed sight without touch.

It will, I know, be generally conceived, that the evidence of sense, the most direct of all evidence, is against the position. Is it possible, it will be said, to be mistaken in a matter so obvious? Do we not see that the objects by which we are surrounded are without ourselves? Can we not extend the hand and take hold of a thing, and can a thing which we hold in our hands be a picture on the bottom of the eye? Or, again: Are not the objects which we see incomparably larger than our whole bodies, much more than our eye, and can the house which we see, or which we inhabit, be only an image in the eye?

PREJUDICES, such as this are strong and not to be readily overcome: but have we not originally had other prejudices equally deep-rooted, which however have been removed by reasoning? Such, for instance, is that respecting the apparent magnitude of the horizontal moon: this notion may be overcome

come by measuring the angle with a proper instrument. Again: the apparent diurnal motion of the sun from east to west: here we seem to have the strongest evidence of sense; but reason in time overcomes this prejudice. And those also stated above may by a little patient attention to plain reasoning be laid aside. They are founded on the supposition that the object of sight is identic with that of touch, and on erroneous notions concerning the general nature of magnitude.

THERE are two modes by which the notion of extension and figure is originally introduced to the mind; by the sense of sight, and by that of touch *. And extension and figure, considered abstractedly, must be the

* Dr. Berkeley has endeavoured, in his *New Theory of Vision*, to prove, that there is no identic object of sight and touch; however, this notion is not generally admitted even by men of science, and some attempts have lately been made to overthrow his doctrine, though very ineffectually. If I have repeated any of Berkeley's arguments I do not apprehend it necessary to make a direct reference.

same, by whatever mode it may become present to the mind; that is, length and breadth are equally length and breadth, whether accompanied by sensations of sight or of touch. The essential properties which constitute a circle or a square are common to those figures, whether brought before the mind by one or the other of these faculties; and therefore the figure, considered geometrically, is the same*; but as one circle may be described on paper, and another on wood, and these circles, though their properties are the same, are not identic, so the extension and figure presented to the mind by sight, is not the identic extension and figure presented to the mind by touch: that is, there is no object common to both faculties.

WE have no difficulty in allowing that sound cannot be the object of the sense of smell, of sight, or of touch; or that colour

* HARRIS Dr. Berkeley and myself differ somewhat in our notions.

cannot

cannot be felt, or the sensations of touch be seen; but since extension and figure cannot be either perceived or conceived unaccompanied with the sensations either of sight or touch, it follows, that the extension and figure as perceived by each must be peculiar to its own proper faculty; and we may with equal propriety pretend to hear smells, or to catch a sound in the hand, as to touch the thing which we see, or to see the thing which we touch. The operation of each is perfectly distinct in its own nature, and the association is only the effect of custom and experience.

WHEN an object is seen by reflection from a mirror, no one would think of associating the tangible notions with it; for instance, let a person take up an orange in his hand, and hold it before a common looking-glass, and he will see the orange in his hand by reflection, but he will not think of affirming that the thing he feels in his hand
and

and the thing he sees in the glass are one and the same. But it has been already observed, that the object seen in the glass and that seen without it are precisely of the same nature, nor can there be the smallest reason in the nature of things for combining the sensations of touch with one rather than with the other, and since they cannot belong to both, they must belong to neither.

THAT the extension and figure perceived by touch are not identic with that perceived by sight, also appears from this, that they separately possess qualities which are quite distinct and incompatible with each other. The extension perceived by touch has three dimensions; that perceived by sight has only two. Solidity, which is a direct object of touch, is no object of sight; on the other hand, a distinction of figure on a plane surface is no object of touch, but is a simple and direct object of sight by difference of colour. Again: tangible figure and magnitude

tude are permanent and invariable, visible figure and magnitude infinitely mutable and fluctuating.

A PROPER conception of this circumstance will tend to correct the above-mentioned prejudices, and enable us to form just notions of the general nature of magnitude, which to human minds is merely a relative quality: we have no knowledge of absolute magnitude, and the magnitude of any object can neither be expressed nor conceived but by means of some other thing with which it is compared.

BUT as visible magnitude and tangible magnitude are not homogeneous throughout, they are not capable of any common measure or standard. Visible magnitude requires a visible measure, tangible magnitude a tangible measure: and since visible magnitude is transient and fluctuating, while that which is tangible is permanent and invariable, we
take

take the latter in general for a standard of comparifon; and the general terms for meafure are taken from parts of the body, the instruments of touch, as an inch, or the breadth of the thumb; the fpan, or fretch of the hand; the length of the foot; the cubit, or fore-arm; the ell, or full fretch of one arm; and the fathom, or full fretch of both arms: all which can only be applied by touch.

It is now, I think, about two hundred years fince the projections on the retina were firft difcovered by the fagacious Kepler; and it was in making experiments on the eyes of animals that thofe projections became known; and they are found to be fimilar to other projections made by lenfes, and founded on the fame optical principles. It does not, however, appear, that this difcovery produced any change in the general perfuafion that the objects of fight are external and remote. The projections on the
retina

retina were considered, not as the things seen, but only as a new-discovered step in the process of vision, and as a set of objects extremely minute when compared with the supposed visible external object.

BUT this opinion of minuteness is entirely founded on a misconception, on a comparison of the things which are seen with an imaginary set of things which are not seen. The external or tangible object can have no relation in magnitude to the visible object. If we should propose to estimate on optical principles, the proportion which the magnitude of the projected image bears to that of the object, we either conceive them both as visible, or both as tangible; in which way only they can bear any relation or proportion in magnitude to each other. But if we consider them as they really are, the one only tangible, the other only visible, there can be no common measure or standard by which the relation can be estimated. Should any one doubt
this,

this, let him conceive two objects, the one only as visible, the other only as tangible, and then attempt to compare them in respect to magnitude, and it will be found impossible: to say, that one is equal to, or greater or less than the other, would express nothing.

THE whole of visible nature consists of a set of objects or figures projected on the retina, which, having a just proportion to each other, agreeable to the laws of visible figure, appear of their proper and just magnitude, which can neither measure nor be measured by any external magnitude which is no object of sight. Our own bodies form a part of this set of visible objects, and our notion of the magnitude of the eye takes its rise from seeing the eyes of others, or our own eyes by reflection from a mirror; and the notion of the minuteness of the picture on the retina arises from seeing the projections in the eye of some other animal, and from comparing those projections with the similar objects

objects which we see direct, and in respect to which they are extremely minute. But it should be noticed, that what in this case the observer sees are not the identic objects which the animal would see with the eyes in his head. The minute objects are not the original projections in the eye of the animal; but *this eye* and these projections are again re-projected on the eyes of the observer, and compared with the original projections in his own eye *. And when Dr. Smith set himself to calculate the magnitude of the picture on the retina of the smallest visible object, it was in fact the magnitude of these re-projections which he was estimating. When, therefore, it is said that an object is much larger than the eye, all that can be meant is, that it is larger than the eye which we see; but this eye which we see is only, like other visible objects, a figure projected on the retina; and the eye, properly speaking, and consi-

* SEE Berkeley's New Theory of Vision, Article 116.

dered

dered as the organ of vision, cannot possibly become an object of sight, nor can we form any notion of its absolute magnitude.

THE above observations will, I hope, be sufficient to remove the prejudices above stated; and we may now proceed to the direct evidence.

FROM a great variety of experiments which might be adduced to prove that the projections on the retinae are the sole objects of vision, I shall select a few which are at the same time extremely simple and perfectly decisive.

It is a fact well known to those who have studied optics, that in a certain position of the eyes the object to which they are directed, though equally projected on each retina, appears single; and it has been generally supposed, that in this case the projection falls on the center of each retina, or on points
similarly

similarly situated in respect to the centres, and these points have by optical writers been called corresponding points.

I SHALL suppose the correspondence of these points to depend on the circumstance of the single appearance of the object projected, and not on a strict geometrical similarity. The fact is well established; and it is also well known, that if by any means the situation of the projection on either eye should be changed, the other remaining the same, two similar objects would become visible, or, as it is generally but very inaccurately expressed, the object would appear double; and as this single appearance cannot be accounted for by any of the known properties of light, or general laws of refraction and projection, it has been made a question, whether this effect is to be attributed to custom and experience, or whether it be the consequence of some original law in the human constitution?

THIS question will be considered hereafter: at present we have only to do with the fact. And it is here to be noted, that though the pictures which fall on corresponding points of the retina appear single, the visible object is composed of the two projections.

IT is easy to conceive, that if two plane figures perfectly similar and equal in magnitude should be applied one over the other, the outlines of the two must coincide and form one figure. The effect of viewing objects through two tubes, one applied to each eye, is well known; if such tubes are properly applied, and two similar objects, as two guineas, placed one in the axis of each tube, the projections will fall on corresponding points of the retina, when the axes of the tubes and the axes of the eyes coincide, and the two guineas will be seen under one outline and become undistinguishable. This effect is similar to what occurs in the ordinary use of the eyes; the two projections
are

are seen under one outline, and the effect is, to render the appearance more vivid.

BUT if, while looking steadily at any object, the globe of one eye be made to move in the socket by means of pressure with the finger, the situation of the projections on the distorted eye must be changed, and one figure will be seen to slide off as it were from the other, and two distinct objects perfectly similar will now become visible, the one situated above or below, on one side or the other, according to the direction in which the pressure is made. This experiment must be familiar to all, and has frequently been noticed by the philosopher; and it is to be noted, that the two objects will be equally accompanied with all those acquired notions which arise from the substitution of visible perceptions as signs of distance, solidity, and other tangible qualities.

But the circumstance to which we are now to attend is this, that the objects we now see are two distinct things, and not one and the same. Writers on vision say, that in this situation "an object appears double." But in this phrase there is a degree of inaccuracy unworthy of science and bordering on contradiction; for the article before the substantive denotes one thing, but the word double denotes two things. What then is a double object? Is it one or two objects? But let us leave words and attend to things. That the objects which in this situation I see are two distinct things, is a clear certainty. They are similar, it is true; but similarity is not identity. That they may be each excited by the same tangible object, I admit; but this cannot make the two things to be only one; and on this circumstance rests the conclusion, that the things seen are the projections on the retinae. It is as impossible for the same thing to be SEEN at the same time in two distinct places, as it is that it should

EXIST

EXIST at the same time in two different places: and as the two things seen have each equal claim to reality and externality, they must be either both real or both appearances; and we can only avoid the absurdity of supposing that external things may be made by pressing the eye with a finger, by admitting that we see only the projections on the retinae; the one is a projection on the right eye, the other a projection on the left. If we now withdraw the pressure, the two objects will be seen to unite or coalesce into one figure; in this case, the single object is composed of what before appeared as two; and as they were not external while separated, the mere junction under the same outline cannot render them such.

AND the reasoning here used will apply equally against the generally-received system of ideas; for this theory supposes a set of external objects, as the archetypes to which the ideas have a perfect conformity, and

consequently the two visible objects in the above case would require two archetypes or external objects.

THE circumstance of seeing objects by reflection from a mirror, has already been considered in the First Section as an instance of erroneous conception on the subject of vision. This simple and familiar experiment may be again introduced as a proof that we see only the projections on the retina; for, as has already been observed, the object seen by reflection has equal claim to reality and externality with that seen direct; the two things are precisely of the same nature, and since they cannot both be real external things, it follows that neither is; and it would be a fruitless attempt to assign any solid reason for ascribing externality to one while it is denied to the other.

ANOTHER familiar phenomenon, utterly inconsistent with the fact of perceiving the external

external object, or any idea corresponding with such an object, is, that of seeing through a polyhedron or multiplying-glass. When an object is seen singly through any transparent substance, as glass, the circumstance is never supposed to affect the reality of the object seen; as no object is conceived to be less real and external from being seen through a window-glass.

SUPPOSE then a glass with three or more plane faces cut on it; on putting this to the eye, we see distinctly as many objects as there are faces on the glass. I ask then, What are these? They are certainly distinct from each other, and, though similar, are not identic. They cannot surely be all external things; but either of them seen through a single face of the glass, or unaccompanied with the rest, would have been accounted a real external object. Their claim then to reality is equal; and since they cannot be all external things, it follows that

not any of them are; the truth is, they are all equally projections on the retina.

THE last argument I have to mention is drawn from the motion of light.

IT is now some years since astronomers discovered that the particles of light had a progressive motion of extreme velocity, which they found means to calculate; and it has been discovered that light takes up about eight minutes in passing from the sun to the earth; from whence it follows, that the visible object which we call the sun is excited by particles of light which had left the sun eight minutes before they arrived at the eye; and the obvious consequence is, that if the sun should be carried beyond the sphere of human perception, or should it be at once annihilated, we should still continue to see for eight minutes that object which we have been accustomed to consider as the sun; wherefore we cannot maintain that

that the object we see is really the sun, without maintaining the absurdity that an object may be perceived which has no existence.

It would be needless to produce more experiments, though many immediately present themselves; and I probably have already dwelt too long on a subject which some writers would have comprised in much less compass. Every circumstance in the above simple and familiar phenomena is utterly inconsistent with the fact of seeing external objects, or ideas which correspond with them; while it is in every particular perfectly conformable with the projections; and we may therefore lay it down as an indisputable fact in vision, that the images projected on the retinae are the immediate and sole objects of the visual faculty. These are the visible perceptions, which by habit are so intimately associated with the objects of touch, as not to be separable in the ordinary

dinary exercise of the understanding; from which association arises that almost insurmountable persuasion, that the thing which we see and the thing which we touch are one and the same.

BUT that externality which the mind is so accustomed to consider as relative to itself, is, in fact, only a relation among the visible objects themselves. We form a conception of the body from what we see; but this, equally with other visible objects, is only a projection on the retina, and the remoteness or externality of an object is nothing more than its situation with respect to this *visible part* of ourselves.

BUT it will perhaps be said, Since it is allowed that the theory now advanced will make no change in the demonstrative part of the science of optics, to what purpose is it brought forward, and what advantage to science will arise from it?

To this I should answer, that it is and must ever be of importance that we should entertain correct notions concerning the operation of the sensitive faculties; and though no immediate advantage to the science of optics may at present result from it, yet it is a fact in the general philosophy of the human mind highly worthy of notice, and from which various important deductions may probably be made respecting percipency in general. The present, however, is not the time for pursuing the subject in that line.

BUT there is one question which has been much agitated among optical writers, in which the position just proved will certainly apply to some advantage; the question is this, Why do we see objects erect by means of inverted images? Every one moderately read in optics must know how much this question has occupied the attention of optical writers; but if we admit the theory
now

now stated, the question itself vanishes; for it implies what is not a fact, namely, that the external objects are seen, and not the images; but the truth is, that the images are not inverted, for the objects we see are erect, and these, it has been shewn, are the images.

THERE is a solution of the above question by Dr. Reid, on which I shall make a few remarks, because the author draws from it a conclusion which I conceive to be altogether inconsistent with the nature of vision; which is this: "that if the projections on the retina had been the reverse of what they now are, the mind would have seen all objects in an inverted position." This author has laid it down as a law of nature in vision, that we see objects in the direction of a line passing from the picture on the retina through the centre of the eye; and by this law of nature he solves the question; since the lines thus passing from
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the extremities of an object projected on the retina must of course cross each other.

BUT this is rather to cut than to loosen the knot ; it is only saying that we see objects erect in consequence of a law of nature ; and when this law comes to be explained, it only expresses the fact itself in other words.

By a law of nature in vision I can only understand some original mode of action arising from the structure of the organ, and its natural effect on the mind ; and not those habits of association which are founded on custom and experience. Thus, the habit of associating the notion of distance to certain visible perceptions, though general throughout mankind, cannot with strict propriety be termed a law of nature in vision, because it does not arise from any circumstance in the structure or conformation of the eye, nor is it deducible from any known

principle in optics, but is founded on experience, or on the habit acquired of combining tangible with visible notions; and it is very possible, that a human being with perfect eyes might be placed in such circumstances as never to acquire this experience, and consequently never to unite to his visible perceptions the notion or conception of distance in a line from the eye; and since the direction of an object from the eye implies this kind of distance, and is indeed a modification of it, it cannot be said that we see objects in any direction from the eye in consequence of any law of nature in vision.

WE know by experience, that an object is only seen clearly and distinctly when the projection falls on a certain point of the retina, generally supposed to be its centre. This point is the centre of the field of view, and the visible place of every other object is determined by its situation on the retina

relative

relative to this centre; and from the habit of directing the eye upwards or downwards, or to one side or the other, in order to bring an object on the centre of the retina, that it may be distinctly seen, is derived the notion of direction from the eye. To *look at an object* is only to bring the projection on the centre of the retina. Dr. Reid's solution therefore only amounts to this, that objects appear erect from the habit of judging them to be in a certain direction from the eye; which I conceive to be only expressing the fact in other words; the question is, What is the foundation of this judgment?

EVERY one knows that inversion is only a relative term. One individual figured object existing in absolute space, whatever might be its situation, could never be in an inverted position, so long as it remained single; two objects at least are necessary to give rise to the relation of inversion; and
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the same holds true of a whole set of objects, which, while retaining their proper relative position among themselves, could never be inverted, whatever might be their position in absolute space. Here some other object, distinct from the set, would be necessary to serve as a standard of comparison, or in respect to which the other might be inverted.

BUT the whole of visible nature consists of a set of figures projected on the retina, made perceptible by the sensation of colour, which, so long as they preserve their relative positions among themselves, cannot be inverted. We call that the upper part which is toward our head or toward the sky, and that the lower part which is toward our feet or the ground; and the same with respect to the right or left hand. But this head or this sky, or the ground or our feet, and the right or left hand, are equally visible objects projected on the retina. That object is
erect

erect whose upper part, or that part which points toward the sky, is posited on the retina toward that part where the sky itself is also posited on the same membrane; and that object is on the right hand, whose position on the retina is on that side of it where the right hand itself is also posited.

NOR does the absolute position of an object in respect to the retina itself determine its erectness or inversion; for in every inclination of the head the general situation of the objects on the retina must alter, while, their relative position remaining the same, the objects preserve their erect appearance. In a recumbent posture the projections will be transverse on the retina, but the erect appearance will remain; and that equally, whether the upper part of the object is projected on the right or on the left side of the retina, according as we lie on one side or on the other.

LET us now suppose, for the thing is possible, a person to be confined from his birth in one position; his limbs and head to be made immoveable, and all intercourse with beings similar to himself to be absolutely precluded. Such an one, his eyes being perfect and his sight free, would have the same *visible perceptions* as another; and whatever may be truly called laws of *nature in vision* would take place in this being; but as he could not, in this situation, acquire the habit of combining tangible notions with his visible perceptions, these last must consequently remain separate and in their original form. Such a being would perceive a constant succession of visible objects appearing and vanishing from sight after various modes. The diminution of apparent magnitude, the various gradations of light and shade, and other circumstances which to us suggest distance, would to him be only a variation of appearance. He would have no notion of the figure of his
 own

own body, or of his own eyes considered as the instruments of sight; and every thing would seem to him as within himself. The position of objects would be in his apprehension only a relation among themselves, but no relation in respect to himself as the percipient; the distance of one object from another would appear only as a distance on the same surface; but of distance or direction from *himself* he would have no idea.

BUT this being would see all objects erect; that is, he would see them in their true relative positions in respect to each other. If he saw a tree, he would see the trunk toward the ground and the branches toward the sky. If he saw a man, he would see his feet on the ground and his head in the air, in the same manner as we do. The objects on his retinae would occupy the whole of visible space. And in order to form the notion of inversion, some object distinct from the things

he saw would be necessary, in respect to which they might be inverted; but such a notion he would not be able to form; and all this would equally take place, whatever might be the real original position of these objects on his retina, whether vertical, in either direction, or horizontal or oblique; for, the position of the objects being merely a relation subsisting among themselves, and no relation in respect to the mind which perceives them, it follows, that so long as they preserved their true relative position in respect to each other, they must appear to the percipient in their proper or erect situation; for there can be no inversion of an entire set of objects in absolute space.

WHEN Dr. Reid then concludes, that if the objects had been originally all projected on the retina in a situation the reverse of what they are now, they would have appeared to be in an inverted situation, I think he totally misapprehends the matter; for,

for, the erection or inversion has no dependence whatever upon the absolute position of the *whole set* of objects. And had this been the order in which nature had placed the objects on the retinae, the notions of touch would, by experience and habit, become regularly associated to this order of appearance; for the body and limbs would in this case have the same relative position in respect to the surrounding objects as they have now.

If it were required, for instance, to reach an object from the ground, or from above the head, we should of course extend the hand toward the place where the object appeared to be situated. If an object were situated on either side of us, we should, in order to reach it, naturally extend towards it that hand which appeared to be on the same side as the object.

UPON the whole then it appears, that optical writers have perplexed themselves in solv-

ing a difficulty of their own making. The notion of inverted images is founded on comparing the set of objects which we do see with an imaginary set of things which we do not see. If we could see the objects as they would appear projected in the eyes of a living body, we should see them inverted with respect to those we saw direct; but, as has been already noticed, the things we should see in this case would not be the real projections in the eye of another, but a minute set re-projected on our own eyes; and since it follows from the common laws of projection, that these minute objects would appear in an order inverted in respect to the real projections in the other eye, we must allow, if we call the former inverted, that the real projections would be erect.

ANOTHER question in vision which has been at least equally agitated with the former is, How we are to account for seeing objects single with two eyes?

It

It is a well-known fact, that in order that the single appearance should take place, it is necessary that the eyes should be in a certain position in respect to the object, or that the projections of the same object on each retina should fall on certain points, which optical writers have called corresponding points; and this correspondence has by some been attributed to custom and experience, and by others considered as the consequence of some original law in the human constitution.

Dr. Wells considers the single appearance as the necessary result of a law whereby objects appear to lie in a certain line of direction; which law is supposed to affect each eye when used singly, in the same manner as when the two are used conjointly; in consequence of which law an object in a certain situation, appearing to each eye to lie in the same line of direction, must of course appear single.

THIS theory of visible direction and its consequences will form the subject of the following Sections*.

* Having throughout the foregoing account of vision spoken of the tangible objects as being real and external; I might perhaps be asked by certain persons, on what ground externality or reality can be attributed to the tangible, rather than to the visible object? But the discussion of this question would lead us into the depths of abstruse, metaphysical reasoning, and is foreign to our present purpose. I am sensible that the principles of Dr. Berkeley and Mr. Hume respecting material existence are adopted by several persons of eminent talents in the present day, and I believe are daily gaining ground. However, I conceive that what has been here advanced respecting vision is not affected by this question which ever way we take it. They who embrace the ideal system must allow that there is a certain process of nature in vision whether the objects concerned in it have any permanent existence independent of the mind or not. The tangible object; the rays of light; the projections on the retinae are not absolute non-entities: they are certain things cognizable by our faculties, whatever may be the nature of their absolute existence; and to these philosophers I should say, that optical writers in general explain the visible object as having a relation to, and connection with, one part of the process, namely, that which we in general consider as the external object, whereas I consider the visible object as being connected with, and dependent upon, a different part of the process, namely, that part which we call the projections on the retinae.

SECTION

SECTION IV.

Dr. Wells's Theory of Visible Direction examined, and the Question, Why Objects appear Single to Two Eyes? considered.*

INOW propose to examine the theory of visible direction laid down by Dr. Wells, and particularly to consider whether it really affords an adequate solution of the question, Why objects appear single when seen by both eyes?

* NOTWITHSTANDING the doctrine I have myself laid down, respecting the true nature of the immediate objects of sight, I find myself in some degree under the necessity of conforming at times to the general mode of expression, and I give this notice, in order to prevent such instances from being brought against me as a contradiction of my own doctrine.

PHILOSOPHY in general would require, equally with the science of chemistry, a new nomenclature and a new construction of phrases, if we would express ourselves with strict accuracy.

I HAVE

I HAVE hitherto considered it as a fact in vision, that objects appear united when their projections fall on the centers of the retinae, or on points similarly situated with respect to the center; but it may be necessary to observe, that in speaking of the center of the eye, or of the retina, and of similar points, I do not conceive that absolute geometrical accuracy is required; for true geometrical figures are mere creatures of the mind, and have no existence among external objects: An absolutely perfect sphere or cube is nowhere to be found in nature. It will, I apprehend, be generally allowed, that in a sound state of the eye the point where the optic axis terminates on the retina may in respect to sense be considered as the center*; and I shall adopt the

* WHEN we consider the use of the eye, there appears reason to suppose it adapted with no small degree of accuracy to its peculiar functions; and I conceive it to be probable, from the nature of the eye considered as an optical instrument, that the ray of light which passes perpendicularly through the center of the crystalline comes to it unbent, and is in fact the true optic axis. If the observations of anatomists are founded

the definition of the optic axis which Dr. Wells has laid down. If the termination of this axis on the retina is not precisely the center, still I conceive that the law of visible direction mentioned by Dr. Smith and by Dr. Reid, will not be affected by such trifling deviation from strict geometrical precision. It is a fact, that points whose projections on the retina are the terminations of these axes, appear united; and the question I mean to consider is, Whether this apparent union is the cause of some law of visible *consequence* direction from the eye? or, Whether it results from some original property independent of any such law of visible direction?

founded on experiments made on the eyes of dead animals, the precise form thus determined cannot, I think, be depended upon. However, it seems an acknowledged fact, that there are certain points of one retina which correspond with certain points of the other; inasmuch, that the objects projected on these points respectively appear united: the correspondence of the points I conceive is founded on this property of producing a single appearance, and not a strict geometrical similarity.

I PER-

I PERFECTLY agree with Dr. Wells in rejecting the opinion of Dr. Smith, who derives the union of these points, or the single appearance, from custom or the habit of correcting visible notions by the knowledge acquired from the sense of feeling; and I should think it a sufficient objection to this solution to say, that if the single appearance is founded on a knowledge of the unity of the external object, derived from the sense of feeling, a single appearance ought not to take place when we previously know there are two external objects; but it is a well-known fact, that two distinct similar objects may, in a certain situation of the eye, be made to appear as one; however, independent of this, there are various other insurmountable objections to this solution.

THERE is an experiment respecting the sense of feeling, which has frequently been adduced as an instance of fallacy in that sense of a similar nature with the fallacies of sight;

fight*; I mean the double sensation occasioned by feeling any object, as a button or a marble, with the opposite sides of two contiguous fingers laid across; but this supposed fallacy is founded on the inaccuracy of our conceptions respecting the unity of an object; for, to speak strictly, the different parts of an extended object are really different things; and it is impossible to feel the same thing at the same time with two fingers, because two fingers cannot at the same time be applied to one and the same part of any object.

THE circumstance which in our judgment constitutes the unity of an object has, in this case, no relation whatever to the sensation. Let a marble be first felt with the fingers crossed, and in this situation the opposite sides of the marble are what we feel with the different fingers. Now, suppose

* This circumstance is mentioned by Dr. Smith in his System of Optics.

the marble to be cut into two parts, and let each part be felt respectively by the same fingers as before, uncrossed; in this situation we should not scruple to say, that we had a feeling of two distinct things; but what we feel now are precisely what we felt before; and I find, that when feeling an object with my fingers stretched apart, but not crossed, I can, with a small degree of attention, catch the same notion of duplicity as when the fingers are crossed; the truth is, the fallacy lies in the judgment we form of the relation which the parts felt by the different fingers have to each other. But in the case of single vision the circumstances are entirely different; for here the very same points of what we call the external or tangible object are seen by each eye. I have adverted to this fact respecting the sense of touch, as serving to shew how apt even persons accustomed to deep investigation are at times to think with inaccuracy.—But to proceed.

Dr.

Dr. Reid is of opinion, that the apparent union of the centers and similar points of the retinae is the consequence of some original law of our constitution; in which doctrine I am inclined to concur, for reasons which will be hereafter mentioned. To this opinion Dr. Wells objects, that it stands in opposition to a very extensive analogy, which teaches us, that when two organs of a similar kind are found in the same individual, the corresponding parts of such organs are found to be at equal distances from the plane of partition; agreeable to which rule, instead of a correspondence between points similarly situated on the retinae with respect to the center, we should have a point on the right side of one retina corresponding with a point at an equal distance from the center on the left side of the other retina.

THIS objection, however, appears to me to have little weight; but while I say this, I must confess that my knowledge in anatomy

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is too limited to render me competent to a full discussion of the question. There is, however, one circumstance respecting the human eyes which, I think, may account for what Dr. Wells terms a violation of a very extensive analogy; this is, the parallel motion of the eyes. If we extend the analogy mentioned by Dr. Wells to the motion of such similar organs, we should naturally expect that it would be in opposite directions; that when one moved to the right the other should move to the left, in order to preserve an equal distance from the plane of partition; but we know that there is a law of motion in the eyes directly contrary to this; and that when one moves so as to increase the distance of the centre of the retina from the plane of partition, the other at the same time moves in such a manner as to cause the centre of the retina to approach this plane.

I UNDERSTAND there are six muscles belonging to each eye which regulate their motions,

tions, of which four are called straight, and two oblique muscles. Now it appears to me, that, agreeable to the rule here mentioned, we ought to expect the corresponding muscles to act at the same time, the external straight muscle of one to act with the external straight muscle of the other eye, and so of the rest; and in that set of motions which regulates the inclination of the optic axes to each other, this really does take place; but in the more general set of motions by which the eyes are carried together to the right or to the left, the external muscle of one acts with the internal muscle of the other: and if it could be shewn, which I apprehend is probable, that in general where there are double organs, the corresponding parts of such organs act together, there would then appear a reason, drawn from the nature of the functions of the eyes, for departing in this instance from the general analogy. To this we may add, that if single vision be the consequence of an united impression or sensation,

which is at least a probable supposition, the general laws of optical projection require, that this property should reside in points, which do not agree with that rule of correspondence which takes place in other double organs whose functions are different: and these considerations appear to me sufficient to invalidate the arguments *à priori* which Dr. Wells has founded on analogy.

WITH respect to those derived from the consequences of Dr. Reid's theory, I have but little to observe. The first is founded on that writer's notion concerning visible place, in which I totally differ from him: original visible place does not include either distance or direction from the eye. In regard to the second, it will, I think, appear that the facts are in favor of Dr. Reid, and that an object at rest does appear to move as seen by one or the other eye alternately, of which more will be said hereafter. The third objection relates to a case of squinting,

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on which I am not competent to say much, never having had opportunities of making observations on such cases; but conceiving them to be anomalous subjects, I should not consider it as making against the general doctrine, even if it should be found, that the points where the optic axes terminate in such eyes do not appear united; and indeed this case is no more to be reconciled to the theory of Dr. Wells than to that of Dr. Reid. Having made these remarks on the objections brought by Dr. Wells against the theory of an original correspondence between the centres and similar points of the retina, we may proceed.

ONE important observation which occurs on the outset of an inquiry concerning the cause of single vision is, that it can be no question with any who maintain that we see external objects, or ideas corresponding with such objects; for if we see external objects, and those objects are single, we must necessarily

see them single; that is, we must see them as they are, independent of any number of eyes.

If the mind is endowed with a power of perceiving external things, the *mode of perceiving* can make no difference in the thing perceived; the number of the organs concerned cannot increase the number of the things to be perceived, and it must be impossible to see two things where there is only one thing to be seen. What has been observed in the preceding Sections renders it needless to dwell on this position here; and indeed it carries its own evidence on the face of it. But considering the projections on the retinae as the direct objects of vision, it becomes a rational and philosophical question, Why, in a certain position of the eyes, the two projections appear united as one, or seen under the same outline? and I profess myself to be one of that class mentioned by Dr. Wells, which considers single vision to be the consequence of an united impression or sensation;

tion; and though it may not be possible to produce such evidence for this opinion as may amount to absolute demonstration, yet I think it may be shewn, that there is nothing in this new theory to set such a notion aside; and that the evidence for it is such as to render it, if not certain, at least highly probable.

THE solution of our author makes the phenomenon of single vision the *consequence* of a certain law of visible direction; but I ask, may not the apparent union of the objects be the original fact, and this law of visible direction a certain consequence of such united appearance?

To account for a phenomenon in nature is to trace it up to some law more general than itself, and of which the fact is one necessary consequence; thus, water rises in a pump from the same principle by which a stone falls to the ground, or by which water descends in rivers to the sea; that is, from

the general principle of gravitation. But this law of visible direction, admitting it to be just, is not more general than the fact it is brought to explain: it is indeed less general; for the apparent union of the optic axes may be considered as being only one instance of the general single appearance of objects.

If it could be made to appear, that the same seeming direction of objects, placed in either optic axis was the original law, we might then consider the united appearance of objects as the *consequence* of such law. But, on the other hand, if the apparent union of objects projected on certain points of each retina is the original fact, the various circumstances of seeming direction, may be deduced from such united appearance.

WHICH circumstance then is prior in the order of things? Was there ever a time previous to the acquisition of certain habits of judging, when objects did not appear
single

single even in that position of the eyes in which we now know that they do? If this question could be answered in the affirmative, it might go a considerable way towards establishing the theory of Dr. Wells as an adequate solution of the question respecting single vision; but we have every reason to suppose the fact is otherwise; circumstances will be mentioned in the sequel which tend to prove that the sensation is united; and we know that the young gentleman touched by Mr. Cheselden, on first receiving his sight, saw objects single, though he thought all things touched his eyes, and therefore could not see them in any direction *from the eye*.

BUT of visible direction we may speak with more certainty; this being a modification of distance from the eye, and necessarily implying it: but it is generally allowed that such distance or the third dimension is no direct original perception by sight, and consequently

frequently the notion of direction from the eye must also be acquired. There is, however, a passage in the Essay on Single Vision which seems to imply, that the writer admits distance in the abstract to be an original perception by sight, conceiving the measure or quantity of such distance only, as not perceivable. The passage is this: "If distance be not immediately perceivable by sight, the only manner in which an original property of the eye can affect the visible places of bodies is by occasioning them to appear in certain directions*, &c." This evidently implies that visible direction, which is a modification of distance, is the consequence of some *original property*. But this is contrary to the general opinion of writers on this subject, who hold that the third dimension cannot be an original object of sight; since the projection of the whole optic axis is merely

* Essay on Single Vision, p. 27.

a single point, and the notion of externality and remoteness is the result of experience, and acquired by degrees.

IN the last Section we imagined a being to have been kept from his birth in such a situation as to have no opportunity of combining tangible notions with his visible perceptions. Such a being as is there supposed would have no conception of eyes as the organs of vision, or as having any relation of direction in respect to visible objects. He would have no notion of the remoteness or externality of the objects he saw, but every thing would appear as within himself, and the whole set of objects would appear as figures variously coloured on a plane surface.

ORIGINAL visible place neither includes distance in a line from the eye, nor direction FROM THE EYE; but is the relative position of the object on a plane, in respect
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to other visible objects, and is to be estimated by its distance and direction, not from the eye, but from some other object in the same plane.

EVERY person acquainted with optics and the nature of vision knows, that what is generally comprehended under the term *seeing*, is a complex operation; an art acquired by degrees, in which judgment and imagination are concerned together with simple perception. It has already been shewn, that the objects which we actually see are only the projections on the retinae. The laws of projection of solid figures on a plane surface have been accurately investigated, and constitute the science of perspective; and the art of seeing may be considered as a sort of anti-perspective, or the re-projection or throwing out of points and lines from a plane into distance and solidity; an art which we begin to practise from the earliest infancy, and whose first im-

imperfect beginnings are beyond the utmost reach of memory.

THE projection of each optic axis is a point on each retina, on or nearly on its centre, and if these points are, as I suppose, united in the mind by some original law of our constitution, forming only one perceptible point, the re-projection, as mentioned above, must in that case be one line. And since this re-projection is not a direct operation of sight, but of some other faculty, that is, as direction from the eye is only adjudged, and not seen, it appears to me, that to say the optic axes appear united in the common axis, is only another mode of expressing the apparent union of the objects, or of the central points of the retinae: in one case, we consider the single appearance as the consequence of the two objects occupying precisely the same place on the *visible plane*; in the other case, we consider the objects as thrown out into distance from the eye; and then we conceive the two as
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appearing in the same direction; and even if we should take up the matter in the latter form, there would still arise this question, Why do the two optic axes appear united throughout their whole length? which is only another mode of stating the question, Why do objects appear single as seen by both eyes? But if we should consider the two circumstances, *united appearance* and *seeming direction*, as being one derived from the other, I conceive it to be most consistent with the rules of sound philosophy, to consider the latter as the consequence of the former, the first being an actual matter of sight and the other an acquired notion, which is properly to be referred to some faculty distinct from simple vision; and I apprehend that every proposed solution of this celebrated question, which derives the single appearance from circumstances which imply externality and remoteness in the objects of sight, must be erroneous and unfounded.

I PRO-

I PROCEED to make some observations on Dr. Wells's propositions respecting visible direction; and I think it will be found, on examination, that it is only from the mode of expression that this theory is conceived to differ from that of former optical writers. I shall adopt the terms and definitions laid down by Dr. Wells, adding to the former the term *optic plane* for that which passes through each optic axis perpendicular to the plane in which the optic axes and common axis lie.

EVERY one knows that direction is a relative term, and that the same object may have various directions as estimated from different points; the direction of one point may also be relative or absolute with respect to some other point, and either of these may vary while the other remains fixed. When we speak of the direction of an object from ourselves, or from the eye, we must consider the eye as a point, and, conceiving some other

other point at a distance, to which a right line may be drawn from the former, all objects in this line, or every point in it, will have the same direction from the eye.

In estimating visible direction we generally have respect to the optic axis; we consider that point which we see most distinctly, or to which we immediately direct our sight, as being directly before us, and it is with respect to this point that we estimate the direction of others, as lying to the right, or to the left, above, or below, &c. Suppose three spots upon a wall at the distance of a foot from each other; when we look direct at the middle spot, we conceive the others to be, one on the right, and the other on the left of the eye; when we look direct on the left spot, we consider the other two as on the right of the eye; and when we look at the right spot, the other two appear to be on the left of the eye: but the absolute direction of each spot from either
eye

eye remains the same in every circumstance. In short, the centre of the field of vision is the point with respect to which we estimate visible direction; a point which, in all the variety of absolute direction, preserves always the same relative direction from the eye or eyes. But we may here remark, that we have no perception of our own eyes as the organs of vision; nor have we originally from nature even a consciousness that we see with double organs; it is impossible that our eyes can become objects of sight to ourselves; and in estimating visible direction, their situation is only a matter conceived in the mind.

LET $ABCD$ *fig. 1*, represent an eye, and let C be that point on the retina where the projections are most distinctly formed; and let P be any distant point whose projection on the retina would be on the point C and join CP ; then will CP be the optic axis, agreeable to the definition of Dr.

Wells;

Wells; in which, I apprehend, Dr. Reid or Dr. Smith would concur. Whether this point C be or not the precise geometrical centre of the retina, or whether the line CP does or does not pass with strict accuracy through the centre of the eye, are circumstances which will not affect the question we are considering.

LET O be some luminous point in the optic axis or line CP, from which a pencil of rays is supposed to issue covering the pupil ED, and which we know will be collected on the same point C*. Now, what Dr. Smith and Dr. Reid have said respecting visible direction is this: that the point O will not appear either in the direction of the ray CE or of the ray CD, or of any intermediate ray between these and the ray CO; but that it will appear in the

* THE point O is supposed to be at some distance from the eye; if it were near, the point C would lie beyond the retina, but still in the optic axis produced.

direction

direction of this central ray CP or CO, which Dr. Smith calls the visual ray, and which in this case is the optic axis; and this, I suppose, no one will deny; for, what is the circumstance which constitutes the being seen in this direction? It is the visible coincidence of the points O and P: the line CP is the optic axis; and if the point O did not appear in the direction of this line, it could not be seen to coincide with the point P, but must subtend some angle with it at the eye; and it is of no consequence in what part of the line CP we take the point P, whether at the supposed concurrence of the two axes, or on either side of that point; it will ever be in the optic axis, and the projection of every point in this line will be on the same point C of the retina, and every other point which is seen to coincide with the point P must appear to be in the optic axis. To this statement of Dr. Smith's theory of visible

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direction

direction I conceive no objection can be made*.

LET us next examine the leading proposition of Dr. Wells, "that objects situated " in the optic axis do not appear to be in " that line, but in the common axis." And it appears from what is said on this subject, that the author considers this law of visible direction as affecting each eye separately and independent of the other; and to hold equally, whether the object is seen by one eye at a time or by both.

THIS proposition certainly appears to be directly contradictory to what we have been considering above; let us then try if we can find any means to reconcile them†.

IN

* I HAVE only considered here the optic axis; but it is obvious that the same reasoning must apply to the central ray of any other pencil of rays, the projection of every point of which will be on the same point of the retina.

† THE lines which Dr. Wells calls the optic axes are not strictly so; for the real optic axes are only apparent points;
but

IN *fig. 2*, let the two eyes be represented at A and at B, and let the axes intersecting each other at the point P be determined as before; join DD the centre of the corneas, and from P draw the line PM to the middle of the line DD; then will PM be what Dr. Wells calls the common axis. Now, we know that the whole of the lines AP and BP, or that every point in them, will be projected on the respective retinae at the same point C*, and consequently cannot appear as lines, but will form only visible points; whereas the common axis PM will be projected as a line on each retina, and will therefore be to each eye a visible line. To speak

but a line drawn from the point of intersection of the axes, in what I have called the optic plane, though somewhat above or below, may be taken for such, without affecting the conclusions; and I shall take the same liberty of calling such lines the optic axes.

* HERE again I observe, that the points of the axis near to the eye are not accurately projected on the point C, but on a point lying beyond the retina in the axis produced; but this circumstance does not any way affect the reasoning here used.

strictly, then, if an object situated in the real optic axis does not appear to be in it, but to be in the common axis, such object must appear to be where the common axis appears to be; but if we should take the proposition in this sense it will not hold to be true. Or, again, we may say, that if an object or a point does not appear to be in the optic axis, such object or point cannot appear to coincide with the point P, which is avowedly in such axis, and then again the proposition will not hold.

THE truth then I conceive to be this: it is not that a point situated in the optic axis appears to be out of such axis; but it is the optic axis itself which we conceive as lying in the direction P M; and the proposition might, I think, have been better expressed by saying, that the two optic axes appear united in the line P M; for in the experiments mentioned by Dr. Wells with different-coloured strings, it is certainly the
line

line CP, or the optic axis, which we see, notwithstanding it seems to us to be situated in the line MP; and, again, that is really the middle line MP which we conceive to be in the situation CP; and that line which we are apt to conceive of, as being one of the optic axes, say the right, is in truth a line which has no respect whatever to the right eye, but is the common axis or line MP as seen by the left eye*.

It would, perhaps, tend to render my meaning clearer if we consider one eye only; and if it should be said, that objects situated in the axis of this eye do not appear to be in it, I would ask, In what line do they appear to be? or, If that is not the optic axis which we see, notwithstanding we conceive it to be in the situation MP, which is the optic axis as seen by this one eye? and we certainly shall find, that there is no other line, that we can conceive as seen

* SEE the 2d proposition in the Essay on Single Vision, &c. page 46.

by this eye, which can have the characteristic property of the optic axis, which is, that every point of it shall be projected on the same point C of the retina.

THE difference then between the two theories appears to me to lie in an ambiguity, the one speaking of an external line, the other, of a conceived or apparent line. But I repeat what I have said before, that no point can properly be said to appear out of the axis which is seen to coincide with the point P, which is confessedly in the axis; and the two theories may, I think, be reconciled, if, instead of considering points situated in the axis as appearing out of it, we conceive the whole axis itself as having a certain apparent situation. However, I lay no great stress on this; for the circumstance of single vision is, as I conceive, perfectly independent of one or other of these theories, or, indeed, of any law of visible direction whatever.

AND what, after all, is this apparent coincidence of the optic axes, but one instance of the united appearance of objects? And as such, how can it afford an adequate solution of the general question? We may still ask, Why do the optic axes appear united throughout their whole length? A question which remains unsolved by any thing contained in the *Essay on Single Vision*; for, to say, that objects situated in the optic axes appear in the same direction to each eye, is only expressing the apparent union in other words. This circumstance has been long known to optical writers, as is evident from the construction of the binocular telescope; and when we consider that the optic axes are only apparent points, and consider further that the notion of direction from the eye, or the habit of throwing points and lines out into distance and solidity, is acquired by degrees, it would surely be more reasonable to derive the apparent direction from the union of the points, than to consider the latter as the consequence of the former.

SECTION V.

Experiments inconsistent with the Theory of Dr. Wells.—An Attempt to explain some Principles which influence the Notion of visible Direction.—Recapitulation.

THE apparent union of the optic axes, when the eyes are used conjointly, does, I believe, in a sound state of the organs, extend to all cases whatever. But I shall produce some experiments which prove that these axes, as seen separately by each eye, respectively, have a different apparent direction one from the other, and each from that of the united axes when seen by both eyes together; which is directly contrary to the opinion of our author, who maintains, that the law of visible direction which he has stated, affects each eye when employed by

by itself, in the same manner as when it is used conjointly with the other*; and the solution which this theory affords of the question respecting single vision rests entirely upon this circumstance.

IN the third part of his Essay Dr. Wells mentions some facts which are inconsistent with his own theory, but which might readily have been accounted for, or even predicted, from the theory of an original correspondence between the points on the retina where the optic axes terminate. But this writer, in order to account for these appearances, has framed an hypothesis, which, though ingeniously adapted to the intended purpose, has not, as I conceive, a foundation in the nature of things; and in subjects of philosophical speculation we must not rest satisfied with ingenious hypotheses.

* Essay on Single Vision, p. 42. 45.

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WHEN the Author, by looking steadily for some time at a luminous body, had acquired the sensation of a spot appearing upon the face of any object to which he directed his eyes, he acknowledges to have expected, that by forcibly altering the position of one eye, the spot would have appeared double, in consequence of a variation in the direction of the optic axis of the distorted eye; contrary, however, to this expectation, the spot neither appeared to be double, nor to have altered its situation: but as the apparent situation of the spot may be changed by certain voluntary motions of the eyes, this Writer concluded, that apparent direction is dependent on the state of action existing in the muscles which move them.

ON this I observe, that the single appearance of the spot would follow, as a necessary consequence of an original correspondence between the points on the retina where the optic axes terminate; for the forcible distortion

tion of the eye could not be supposed to affect such an original property. The spot is a sensation or durable impression on a certain part of the retina caused by a strong light; and while the various objects projected on the retina change their positions, in respect to its centre, in consequence of the forced distortion, it is evident, that the affection of the central part, caused by the strong sensation of light, must remain as before the pressure of the eye, and the spot must therefore appear united with that seen by the other eye, wherever it may appear to be; and the double appearance of other objects readily follows from the same source; for those objects are, by the pressure of the eye, protruded from those similar points, which they before occupied on the retina, and on which their single appearance depends; while the objects whose projections now occupy these points will appear to be united with the former objects as seen by the other eye.

I PROCEED to state some simple and plain experiments that are not to be reconciled with the theory of visible direction which we have been considering.

EXPERIMENT I.

AFTER looking steadily for a little time at any object, for instance, a lighted candle, at the distance of three or four feet, let the eyes be closed alternately, the object being seen by only one at a time, and it will appear to have a motion from side to side, seeming to move to the right when seen by the left eye, and to the left when the right is used; and when seen by both eyes at the same time, it will appear midway between the two places where it appeared to the different eyes singly.

WHEN I first tried this experiment I closed my eyes alternately with my fingers; but apprehending it possible, that some deception

ception might arise from a motion communicated to the eye by the act of closing it with the fingers, I procured two elliptic pieces of card of about two inches and a half in length, and two in breadth; these cards were blacked, and pasted on two small sticks of about eight inches in length to serve as handles. With these cards I repeated the experiment, keeping both eyes open, and continually directed to the object, but alternately placing a card before one and withdrawing it from the other, when the result was as before, and the object had an obvious apparent motion from side to side. This experiment I have very frequently repeated with the same appearance, and have caused various persons who were occasionally with me to try the same, and always with the same result.

EXPERI-

EXPERIMENT II.

LET A and B *fig. 3*, be the places of the eyes, and P the mutual interfection of the optic axes when they are directed to the point P. Draw PM to the middle of the visual base. Let O be any point or object in the right axis BP, and join OA and OM; then will PM be the common axis, or the line in which both axes appear to be united when the eyes are both directed to the point P, and OM will be the common axis when the eyes are directed to the point O; and, agreeable to the theory of Dr. Wells, the apparent direction of the points P or O, when the eyes are respectively directed to them, will be the same, whether they are seen by one eye singly, or by both at a time.

I PROVIDED myself with a thin board about eighteen inches square, on which I pasted white paper; this board was fixed on
a stand

a stand similar to a fire-screen. Through a small hole made in it I passed several differently-coloured strings held fast by a peg, and on each string I put a bead of a different colour. This formed a very simple and convenient apparatus for trying the experiments mentioned by Dr. Wells, as well as many others.

WITH this apparatus I held one of the strings in the axis of the right eye, or, more strictly speaking, in the right optic plane somewhat below the axis, for I held it with my teeth on the right side of my mouth. The bead, which may be represented by the letter O in the *fig.* I placed about midway between the eye and the point P, and held in each hand one of the cards mentioned in the former experiment. Now I found, that when the card was held before the left eye so as to intercept its sight, the bead or point O appeared to have precisely the same direction, whether my eyes were directed

directed to it or to the point P. This I tried frequently, alternately directing my eyes to one and to the other, without observing the smallest apparent motion, or any variation in the direction; but as soon as I withdrew the card from before the left eye, the two being directed to the point O, it immediately appeared to have a direction lying to the right of the former; and on covering the right eye, this direction became still more inclined to the right; withdrawing the card from the right eye, and covering the left, the point O resumed its former situation; and thus I tried it for a number of times with the same result. When I alternately placed a card before one eye, at the same time withdrawing that placed before the other eye, the apparent motion of the bead became extremely obvious.

THERE is, however, a circumstance which might lead to deception in this experiment; which is, that when one eye only is used

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we may suppose the eyes to be directed to the point O, when in fact they are directed towards P, which would render the visible circumstances, on withdrawing the card from the other eye, somewhat different; in order therefore to obviate the possibility of being thus deceived, I varied the experiment in the following manner:

EXPERIMENT III.

ON the screen above-mentioned I drew a perpendicular line, in which I made a mark which we may call P*, and from an arm fixed to the stick of the screen, I hung a plumb-line at the distance of about eighteen inches from the screen; on this plumb-line I fixed a small piece of card, on which a word was written in a small character. This plumb-line, being interposed between the eye and the perpendicular line drawn on

* In *fig. 3.*

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the

the screen, at a nearly equal distance from each, might easily be brought to lie in either optic plane, by making it appear to coincide with the perpendicular line on the screen, as seen by either eye.

I now situated myself so as to cause the plumb-line to lie in the right optic plane; and when the eyes were really directed to the point P in the perpendicular, the letters written on the card appeared too confused for the word to be legible; but when the eyes were really directed to the card, which in this experiment is the same as the point O in the 3d *fig.* mentioned above, the letters appeared distinct, and the word was plainly legible; and by these means I avoided being liable to the deception above stated.

Now, when the blacked card intercepted the sight of the left eye, the two eyes being directed alternately to the point P and to the
card,

card, the result was precisely as before, no motion or alteration of direction appearing, whether the eyes were directed to one or to the other of the objects lying in the right optic axis; but as soon as the card was removed, the eyes being directed to the bit of card on the plumb-line, or the point O, its apparent direction appeared to be moved to the right. When the cards were alternately used, the apparent motion became as before extremely obvious. And it is worthy of remark, that when both eyes were held directed to the perpendicular line on the screen, both it and the plumb-line appeared to have a motion together from side to side, though not in equal degree, the plumb-line appearing to move through the greater intervals.

IN this apparent motion of the optic plane there would have been nothing extraordinary had it appeared to move on the perpendicular line as a centre when the eyes

were directed to this line; but in this case the centre of apparent motion lay more remote, and the perpendicular line, as well as the plumb-line, had an apparent motion from right to left, as one or the other eye was used.

THIS experiment may be varied, by making the object in the optic axis, here represented by O, a card with a hole in it about half an inch diameter, and fixed at the distance of about two feet and a half from the eye; by looking at some object at a little distance through the hole, the card may be kept in the optic axis; and when the eyes are directed to it and alternately covered, the apparent motion cannot be overlooked.

EXPERIMENT IV.

LET A and B *fig. 4*, represent the eyes, and the line AB the visual base; upon the point M, equally distant from each eye,
erect

erect the perpendicular P M, in which take the points R, S, T, at any intervals, and join A R, A S, A T, and A P, and also B R, B S, B T, and B P; then will the line P M be the common axis while the eyes are successively directed to the points R, S, T, and P. Now, agreeable to the theory of Dr. Wells, the points R, S, T, and P, as the eyes are successively directed to them, ought to appear to be in the same direction, and the axes consequently to be at rest, notwithstanding their real motion; and this ought to take place equally, whether one eye or both be used at a time, the law of direction, agreeable to this Writer, affecting each eye when used singly, the same as when both are used conjunctly.

ON one of the strings in the apparatus already described, I placed several beads at intervals, and held the string in the common axis or line P M. Now, when both eyes were employed, and successively directed to

the points R, S, T, and P, each point appeared, agreeable to the theory, to lie in the same direction; namely, in that of the line PM; but when the black card was held before the left eye, and the two again successively directed to the points R, S, T, they appeared each in a different direction, and the right optic axis had an apparent motion corresponding with its real motion from left to right.

FROM these experiments the following consequences obviously result:

FIRST, That an object, though situated at the concurrence of the optic axes, and consequently appearing single, has a different apparent direction as seen by either eye separately, or by both eyes conjointly; and therefore the single appearance of objects in a certain position of the eyes, cannot be the

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consequence of a law of visible direction affecting each eye singly in the same manner as when the two are used in conjunction.

But, on the contrary, since the apparent union of objects projected on certain parts of the retinae, when seen by both eyes, is a well-known and established fact; and since an object thus seen single has a certain apparent direction, lying midway between the two seeming directions, which the same object has, when seen separately; it is surely reasonable to consider this intermediate direction as being compounded of the other two; and as the natural result of the united appearance.

SECONDLY, Different points in the same optic axis to which both eyes are alternately directed, do not, when one eye is covered, and they are seen only by that eye in whose axis the points lie, appear to have a different direction. And since there is, as avowed by Dr. Wells, a difference in the state of

action in the muscles of the eye which alternately looks at the objects or points, it follows, that apparent direction is not dependent on such state of action in the muscles; for, in this case, the direction remains the same, while the state of action changes. But as the apparent direction alters when the object becomes visible to the other eye, without any change taking place in the state of action in its muscles, we must search for the cause of this seeming change of direction, in some *visible circumstance* affecting that eye by which the point or object is last seen.

WITHOUT pretending to bring forward a perfect theory, which may account for all the phenomena of the seeming direction of visible objects, I shall point out some of the circumstances by which I conceive it to be influenced.

THE

THE first observation I have to make is, that, assuming as a fact, the existence of some original property in the similar points of the retinae, in consequence of which objects projected on these points appear to be united, we may from hence deduce the direction of the apparently-united optic axes as lying in the common axis; for, the projection on the right eye of that line which we have all along called the optic axis*, will be a vertical line passing through the centre of the retina†; and the projection of the left optic axis on the right eye will be a line extending to the right of the centre, and making a certain angle with the former. Again, in the left eye, the projection of its axis will also be a vertical line passing through its centre, and the right axis will

* It has already been observed that these lines are not strictly the optic axes.

† I must beg leave to remind the reader of what I have already said respecting geometrical precision in speaking of that point which we call the centre of the retina.

be projected on this eye in a line extending to the left of the centre, making an angle with the projection of the axis precisely similar to that in the other eye.

Now when, in consequence of the above law, the two vertical lines or optic axes appear united, it is obvious that this united line must appear to make equal angles with the left axis on one side, seen by the right eye, and with the right axis on the other side seen by the left eye. So far we are clear; but any attempt to explain all the various phenomena of seeming direction from the laws of projection, must prove fruitless; let us, then, have recourse to other considerations,

In what follows, I shall call the whole collection of visible objects seen at one glance, or while the optic axes remain in one position, the field of vision; and this, whether one eye only is used at a time, or the two conjointly. This field of vision originally,
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and previous to all experience and exercise of the judgment, is a visible surface differently coloured; and it is obvious, that the point of concurrence of the optic axes will be the centre of this field, in respect to which we estimate the direction of any other point as lying to the right or left, or above or below, &c. Or, conceiving this visible surface as thrown out into distance and solidity, we may consider the field of vision to be divided into a right and a left half by a vertical plane, which dividing plane must evidently appear or be considered only as a perpendicular line. When the two eyes are used conjointly, this dividing plane will be the two optic planes appearing united; when one eye only is used, the vertical plane dividing the field of vision into two equal parts, will be the optic plane of that eye which is used.

WE may observe, and the observation is of more consequence than may at first appear,

pear, that there is no original feeling or immediate consciousness in the mind, by which it knows whether it sees with one or the other eye. We may, from experience and a comparison of circumstances, be able to determine this, but not by any original sensation ; and, indeed, there are many who would scarcely be able to pronounce whether they saw with one or with both eyes : and I was acquainted with a most respectable and well-informed person, who declared that one of her eyes had been deprived of its sight some months before she discovered her loss. But since the visible circumstances attending the same object are different as seen by one or by the other eye, the judgment must of course be under the influence of such circumstances.

SUPPOSE a cube to be placed in such a situation, that one of its sides, say the left, should lie precisely in the right optic plane, it would follow, that if the right eye only
were

were used, this left side could not be seen, two sides only of the cube would be visible, either the upper or the lower, and that one fronting the eye; but if the object were viewed at the same time by the left eye, the left side of the cube would become visible.

WE may suppose another cube similarly placed in the axis of the left eye, and the circumstances would be the same.

HENCE it appears, that when the two eyes are used, the field of vision consists of objects of which some are seen with both eyes, and others are seen only by one eye; and from this circumstance there arises, a seeming increase of visible space, when the optic axes cross each other. And hence also, it is obvious, that the field of vision, as seen by each eye separately, will be different; for, when the right eye only is used, the field of vision must tend to the left, and when the left eye is used, it must

for the same reason, incline to the right; and, therefore, when the two eyes are used conjointly with the axes inclined to each other, the field of vision must be increased, being extended to the left by the right eye, and to the right by the left eye; and different fields of vision must require different planes of partition.

A FIGURE will assist our conceptions of this matter.

LET AP and BP , *fig. 5*, be the optic axes crossing each other in the point P , the eyes being supposed at A and B , and let PM be the common axis determined as in the former figures, bisecting the angle APB . Then if the line CD is drawn perpendicular to the axis AP , it is evident, that no point lying behind this line, or on the side opposite to that on which the axis lies, can possibly be projected on the eye at A . Therefore this line CD may be considered as
limiting

limiting the field of vision of the eye at A, while the axis is directed to the point P: in the same manner, the line EF will limit the field of vision of the right eye at B, and the point of intersection of these lines will, in this case, be in the common axis PM. Now it is evident, that the angle CME or FMD made by the intersection of the limiting lines, is equal to the angle APB, the inclination of the axes; and by drawing LG perpendicular to PM and bisecting the angles CME and FMD, it appears that when the two eyes are used the measure of the whole range or field of vision will be increased by the angles LME and DMG, equal together to the inclination of the two optic axes.

WHEN the right eye is used alone, the plane dividing the field of vision will lie in line BP, and will be the right optic plane; when the left eye is used singly, the field of vision will be divided by the left optic plane

plane passing through the axis AP ; but when the two eyes are used conjointly each optic axis becomes an object of sight to the other eye respectively, thus interposing, as it were, new visible space; and the range or field of vision, comprehending the angular space EMD , must be divided by a plane passing through the line PM , which bisects that space or range, and which will be the two optic planes apparently united and passing through this line *.

HENCE we may derive a reason why an object situated at the concurrence of the op-

* It may be necessary to remark here that I do not mean to advance the above as a general proposition, that extends precisely to every possible case of vision: the case here considered is that of direct vision, or of the general and ordinary use of the eyes. And my intention is only to convey a notion of the general principle which influences the seeming direction of an object as seen by one or the other eye, or by both together. In cases of very oblique vision the object to which the optic axes are directed is not considered as the centre of the field of vision; but in general; the use of the right eye causes an object to appear more to the left, and the use of the left eye makes it tend to the right.

tic axes has an apparent motion, or appears to have a different place as seen alternately by the one or the other eye singly; for the field of vision being in these cases different, it must require a different centre or plane of partition; but the object at the concurrence of the axes must be in the centre in either case, and therefore the mind refers it to a different place, to the right or to the left, according to the eye which is used; and for the same reason it is referred to a middle situation when both eyes are used conjointly.

I AM fearful that a wish to be clear may render me tedious. It is, however, better to be a little prolix than obscure; I shall, therefore, farther illustrate this matter by another *figure*.

LET A and B, *fig. 6*, again represent the eyes, and AP and BP the optic axes crossing each other in P as before. Let C and

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D be

D be two objects in the left axis at equal distances on each side the point P, and E and F two other objects in the right axis at the same distances from the point P.

Now, if the left eye should be used, the objects E and F would appear as lying one to the right and one to the left of the plane of partition ; but the two objects C and D would appear to coincide with this plane. On the other hand, should the right eye be used, the objects C and D would now appear to lie one to the right and one to the left of the dividing plane, and E and F would be the coinciding objects. Should both eyes be used together, D and F would be two right-hand objects ; namely, D a right-hand object to the right eye, and F one to the left eye ; and E and C would be the two left-hand objects, E being one to the left eye and C one to the right eye ; and the dividing plane would now seem to lie in the direction P.M.

WITH

WITH the apparatus already described, all this may be actually put to the proof of experiment with much ease. In this case, the point P situated at the concurrence of the axes will be respectively referred to three different places. When the left eye is used, it will be referred to the same place as the object D, with which it will appear to coincide. When the right eye is used, it will be referred to the same place as E for a similar reason: and when both eyes are used, it will be referred by the mind to a place lying midway between the former two.*

UPON the principles now stated, we may be able satisfactorily to explain various phenomena of seeming direction from visible circumstances, without having recourse to the

* Besides the four objects which are in this case seen, of which two appear on the right and two on the left side of the plane of partition, all the four, C, D, E, and F, will also be seen united in the line PM, or as lying in the plane of partition; the first are seen two by one eye and two by the other; the last are seen each by both eyes together.

state of action in the muscles which move the eyes. For instance, that while an optic axis retains the same real position, an object situated in it may seem to have a variety of different directions. If the right axis should remain fixed, and the eyes be successively directed to different points in it, the field of vision, both eyes being used, must change with every successive point to which the eyes are directed; if from a remote point to one that is nearer, so as to increase the inclination of the axes, the field of vision, and consequently its plane of partition, will tend towards the right, and the point where the axes cross each other will be referred to a situation more towards the right, as being the apparent centre of the field of vision. This may be rendered very plain by attending to the apparent circumstances of a cube, as before mentioned, one side of which is supposed to be situated in the right optic plane: when seen with the right eye only, this side of the cube will lie in the plane which appears to divide the field of vision;

vision ; but when seen by both eyes the side before invisible comes into view ; and the effect in respect to the mind is precisely the same as if the cube were to be removed to the right as to render the left side of it visible ; for, as was before observed, there being no original feeling by which we can distinguish that which is an object of sight to one eye from what is an object of sight to the other eye, the judgment and conception are influenced by the apparent circumstances. The nearer the optic axes approach to parallelism, or the more remote the cube is from the eye, the less the field of vision tends to the right ; and in an increase of the inclination of the axis, the left side of the cube, having a more direct appearance in respect to the left eye, must appear more to the right.

AND that the judgment respecting direction is, in this case, influenced by the *visible circumstances*, and not by the state of

action existing in the muscles, is evident from the Second and Third Experiments; for, when the objects were seen by the right eye only, the sight of the other eye being intercepted by the interposition of the black card (a circumstance which could not prevent its motions from corresponding with those of the other eye) the direction of the points O and P* remained unchanged, whether the eyes were directed to one or to the other. Here then we have an instance of apparent direction remaining the same, while the state of action in the muscles changes; on the other hand, while the eyes continued to be directed to one of the objects, as O, it appeared to have a different direction as seen by one eye singly, or by both at the same time; which is an instance of change of apparent direction while the state of action in the muscles remained the same. The real circumstance which influenced the mind in the seeming direction being

* SEE *fig. 3.*

this,

this, that when the left eye was uncovered, the space OP of the right axis, which was before invisible to the right eye, now became an object of sight interposed between O and P , similar to the side of the cube.

AND upon the same principles is to be explained the reason why, in different real positions of the optic axes an object situated in them may appear to have but one and the same direction. For, when the eyes are successively directed to different points, all lying in a line perpendicular to, and bisecting, the visual base, it is evident, that while both eyes are used, the field of vision will in each case be divided by the same plane; for, notwithstanding the extent of the field, or the range of sight, is contracted as the eyes are directed to the more remote points, and the axes approach to parallelism, yet the contraction being equal on the right and on the left side, the plane of division must, throughout, re-

main fixed; and the optic axes appearing to be united in this plane, it follows, that their apparent direction, or that of an object situated in them, would remain the same in various changes of their real position. But if one eye only should be used, and successively directed to the several points, there would in each case be a different field of vision, each lying to the right of the other, and consequently requiring a different plane of division, and different centre, and the axis of the eye would then have an apparent motion to the right corresponding with its real motion: all which appears clearly from the Fourth Experiment.

AND here again, we have an instance of a seeming change of direction, while the state of action remains unaltered; for, while the two eyes are held directed to any one of the points, its apparent situation varies as one or both eyes are used.

SUCH

SUCH are the observations which have occurred to me in examining the theory of visible direction laid down by Dr. Wells. In the preceding section my intention was to point out that, even admitting the facts stated in this theory, it would not necessarily follow, that single vision was the *consequence* of such a law of direction; for, direction in a line from the eye being an acquired notion or conception, and the single appearance an actual matter of sight, it would seem more reasonable to consider the apparent union of the points where the optic axes terminate on the retina as the original law, and from thence to derive the law of direction; for, if the two points are united into one by some original sensation or impression, the re-projection or throwing out of this united point into distance can only constitute one line. However, in the present section, the experiments which are brought forward prove, that the point of intersection of the optic axes has a different seeming direction as seen by one or by the other

other eye, or by both at a time; which reduces the matter to a certainty; since, in order that the single appearance should be *caused* by a law of visible direction, it is necessary that this law should affect each eye when used singly, in the same manner as when used in conjunction with the other; and such Dr. Wells maintains to be the case; but all the experiments here mentioned, and I have tried them over and over again, are inconsistent with this opinion. But, since an object, if it appear single to the two eyes, must, at the time it is so seen, appear to each eye to be in the same place; that is, since one visible object can only have one visible place at one time, and since this place is not that which it has when seen by either eye singly, we may safely conclude, that the apparent place of the object when seen by both eyes is dependent on the circumstance of its being seen single.

IN

IN canvassing the opinion of Dr. Wells, I have only made use of that liberty to which all have a claim in treating philosophical subjects; and I trust, that while producing a direct opposite opinion, I have not, anywhere, expressed myself in terms which can with reason give the slightest degree of offence to that Writer.

IT remains to state the evidence we have for considering the united appearance of objects seen by both eyes to be the consequence of an united impression or sensation; this will be the subject of the following Section*.

* BEFORE I proceed to the next Section I wish to make a few remarks on a certain phenomenon of vision which is mentioned by Dr. Wells in a note in the 105th page of his Essay, for which I have not been able to find a place before, as the principles concerned here are very different from those we have been considering.

THE experiment is this: If a small hole be made in a card and held near to the eye and some opaque body, as a needle, be passed between the eye and the hole, there will be seen two objects, one the needle itself passing in one direction over the hole, the other a shadow of the needle passing in
a con-

a contrary direction, and seeming to be on the other side of the card.

I do not enter on the explanation of this phenomenon with a view to controvert the principles on which Dr. Wells has accounted for this appearance, which, as he justly says, lie on the very surface of optical knowledge; but the account he has given of this experiment, and of that of Mr. le Cat, which gave rise to the note, appears to me to be imperfect, as it kept me in doubt, while reading it, whether the shadow as it is called, was the only object which was seen in the experiment. The solution of Mr. Harris hinted at in the note, which is all I know of it, is certainly just, "that it is not the needle but its shadow on the other side which is seen." As the experiment may be new to some who have not been in the habit of studying this subject, I have introduced this account in order to shew how readily we may fall on the true explanation of such phenomena by having immediate recourse to the projections on the retina.

LET AB, *fig. 7*, represent an eye, and the point P the hole in the card, which, if held up against a strong light, may be considered as a luminous point. Let R and L be any two distinct, external, or tangible objects, namely, R one on the right hand, and L one on the left, whose projections on the retina will be at *r* and *l* respectively, then we must consider *r* as the right side on the retina, and *l* as the left, and a figure or body passing over the retina in the direction from *r* to *l*, will appear to move in that direction which we call from right to left. Now, suppose the card with the hole in it to be held so near the eye that the accurate projection of the hole or point P shall fall beyond the retina at *p*; the pencil of rays PAB, which issue from the hole and cover the pupil, will be diffused over a part of the retina in a small circle represented by *fg*; now that half of this small luminous circle which lies on the retina towards *l* will appear as being the left half, and is formed by rays which enter the pupil on the side B, or on the right side in respect

respect to the external object R, and that half which lies on the side towards *r* will appear as the right half, and is formed by rays entering the pupil on the side A, or the left in respect to the object L. Suppose the needle to move along the line CD in the direction from C to D, or from right to left, respecting the external object, then will the projection pass over the retina in the direction from *r* to *l*, which is from right to left on the retina; but when it comes to F it will begin to intercept the rays which form the side of the luminous circle on the retina towards *l*, that is the left side, and must therefore efface part of the left side of the circle, appearing as a shadow, while the needle itself will appear on the right side: and so as the needle proceeds from right to left it will successively intercept the rays which form the circle, in the direction of *l* to *r* or left to right, contrary to the motion of the needle, and appearing as a shadow. When the needle arrives at the central ray, the projection of the needle and the shadow become one object, the projection of the needle itself in that situation effacing the central part of the luminous circle; as the needle proceeds to the left, the right side of the circle becomes obscured by the interception of the rays which enter on the left side of the pupil, and which form the right half of the circle.

AND the shadow has the appearance of an object passing beyond the card, which I suppose is owing to the circumstance of its being visible only while passing over the diameter of the circle or of the hole in the card.

THE same principles would apply to a motion in a vertical direction, and cause the inverted appearance of the shadow.

SECTION

SECTION VI.

*Arguments and Experiments tending to prove
that Single Vision is the Consequence of an
united Sensation*.*

I AM now to state the evidence which tends to prove that the eyes are endowed with some original property, in consequence of which the impression made on a certain point of one retina is united with the impression made on a certain point of the other retina; and that the united appearance of the

* THE Author knows little of what may have been already written on this part of his subject. M. du Tour made some experiments similar to what are here mentioned, but the consequence he drew from them was very different from what is here advanced.

pro-

projections in a certain situation of the eye arises from this united sensation.

HOWEVER decisive this evidence may be to my own mind, I do not pretend that it amounts to absolute demonstration; but it appears to me fully sufficient to render the proposition highly probable, where the mind is not under the influence of a previous attachment to some different theory.

THE first argument to be produced is founded on the analogy of nature. It is a fact well-known to anatomists, that in the human species the optic nerves unite in the *fella turcica* before they enter the brain: and a similar union takes place in various other species of animals. But, if I am rightly informed, there are some species of animals whose eyes are so situated as to look to opposite sides, and consequently not to see the same object at the same time with both eyes,

eyes, in which such a junction does not take place. Without inquiring into the manner in which this union is formed, we may suppose that nature had some purpose to answer by it; and it seems probable that it may have some relation to single vision, and may cause this by uniting the sensations. The circumstance, taken singly, may not be thought of much consequence, nor do I lay much stress on it; but it serves to corroborate when united with other facts*.

ANOTHER circumstance I have to mention, which makes in favour of the position, is what happened to the young gentleman

* An ample field of research seems to lie open to the anatomist respecting the brain, of which, from the peculiar nature of its substance, our knowledge is extremely limited. But I should hope, that in the present highly-improved state of every art, means might be devised for developing the hitherto inexplicable folds of this most curious substance, and for explaining the nature and the mode of its very important functions.

couched

couched by Mr. Cheselden. It appears, that on first receiving his sight he thought that all objects *touched his eyes*; that is, he saw the projections on his retinae, without associating with his visible perceptions the conception of distance or of direction in a line from the eye; but it does not appear that he ever saw the objects he looked at double. This proves, as far as one instance can go, that single vision is original, and that it does not depend upon any law of visible direction.

I PROCEED now to produce some simple experiments, which favour the notion of an united sensation.

EXPERIMENT I.

THEY who are accustomed to use spectacles know, that the two rings appear to unite and to form one circle. Into the rings of a pair of common spectacles let two pieces

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of

of stained glass of different colours be fixed; and if these spectacles should be worn in the common manner, it is evident, that over one of the retinae will be diffused rays which excite one colour, and over the other retina will be diffused rays which excite some other colour; and the consequence will be, that neither colour will be singly perceptible, but that some intermediate colour will be seen. If the eyes should be alternately closed, so as to exhibit the two colours singly, one succeeding the other, and immediately after both eyes should be kept open, the intermediate colour will be made very perceptible. This experiment alone would be perfectly decisive to my mind; but it will not, perhaps, produce the same degree of conviction in others, particularly in such as may have admitted some theory different from that now proposed.

BUT let us reflect on the true nature of colour, and on the true nature of vision.

Colour

Colour we know to be a sensation excited by the action of light; but here we have rays acting on either retina, whose single effect would be to produce some colour which in this case is not perceptible. What then is that intermediate colour which we see, and how does it arise? It is an effect, and requires some cause; and it is an effect which can only be produced by the action of rays of light on the optic nerves; it therefore must be the joint effect of the rays acting on the two retinae, or an united sensation.

THIS experiment may be varied by using, instead of spectacles, two tubes with the infides blacked, and differently-coloured glasses fixed at the extremities farthest from the eye. When such tubes are applied to the eyes, it is evident that if the axis of each tube coincides with the axis of each eye respectively, the apertures at the ends will be projected on the terminations of the optic axes,

or on similar points of the retina; but if one of the tubes should be so moved, that its axis should no longer coincide with the optic axis, the aperture at the end would be projected on some part of the retina dissimilar from that of the other. In the first case the two tubes, as with a binocular telescope, appear to coincide and to form one, and the aperture will appear to be of some intermediate colour, as in the instance of spectacles; in the latter case, the two tubes will appear separate and distinct, as will also the colours of the apertures. But the tubes may be held in such an intermediate situation, as that part of the apertures shall fall on corresponding points, and part on points which do not correspond; in which case the two colours will appear distinct on the separate parts of the apertures, and the third or intermediate colour will appear on that part of the aperture which is united, or which falls on the corresponding points of the retina.

IN making these experiments some circumstances are to be noticed, a want of attention to which, might lead some to suppose that the experiments did not answer.

WHAT is generally understood by deepness of colour, is not occasioned by the density of the rays, nor by the intensity of their action, but proceeds from their rarity. A few rays of any colour diffused over a part of the retina would excite the notion of a dark colour; for deepness of colour approaches to blackness, which is the privation of colour or sensation. If, therefore, we look through a glass deeply stained with any colour with one eye, and should either not apply any, or only some light-coloured glass to the other eye, it is not to be supposed, that the general appearance will be that which might be compounded of a deep colour mixed with white or with some light colour; for the eye which sees through a dark glass will be affected only with a weak

sensation, which consequently can produce but little effect on the sensation of the other eye ; and if the stained glass should be still deeper, we might not be able to see through it at all ; while the sensation of the other eye would remain perfect in the same manner as if one eye was closed.

HENCE, when we apply to the eyes glasses stained with different colours, we are not to expect that the colour compounded of the two will have the same appearance as if we looked through both glasses with one eye. If a blue and a yellow glass are placed one before the other, and applied to one eye, the appearance will be that of a full green ; but if the same glasses should be applied, one before each eye, as in the experiment of the spectacles or tubes, the colour will be a green diluted with much white light, or a pale green ; for when the glasses are placed one before the other, the two in this position intercept much more light than when they

they are separate ; and this for a reason which must be obvious to all who are acquainted with optics.

AND therefore in the above experiments it is not necessary that the intermediate colour be such as might previously be expected from a mixture of the two colours of the glasses ; it is sufficient for the conclusion we draw, that any colour should be seen different from that of either of the glasses singly*.

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EXPERI-

* IN a note to the " Essay on Single Vision with Two Eyes," page 45, Dr. Wells observes, " that in all his experiments of seeing two differently-coloured objects, one with each eye, with the eyes so situated as to cause the objects to appear united, the two objects, notwithstanding their apparent union, appeared each in its proper colour ; as a red appearing as it were through a transparent green, and a green through a transparent red, &c."

WHEN I have attempted to see two objects of different colours, one in the axis of each eye, I acknowledge that the result has not been agreeable to my expectation ; for at times I saw only one of the objects, at times only the other ; but when I caught the two objects united, there certainly was a colour seen distinct from that of either singly, though

not

EXPERIMENT II.

I PROVIDED a piece of pasteboard of about one foot in breadth and two in length; one end I cut so as to adapt it to the profile of my face, in such manner, that when applied to it in a vertical position perpendicular to the plane of the face, the rays which came to one eye were intercepted from the other. I then placed a sheet of white paper perpendicularly against a wall to which a

not that which might have been previously expected from the composition of the two. And I apprehend that Dr. Wells, in the experiment he mentions, has been apt to confound imagination with sense; for I conceive it to be impossible to see one colour through another.

WHEN we look at an object of known colour through a stained glass of any other colour, we are apt to think we perceive two colours at the same time; but it is probable that in this case the imagination is employed at the same time with sensation; that is, from knowing the colour of the object we conceive it to be of one colour, while we see it of another; and I apprehend it may be laid down as a maxim in vision that the same individual point cannot appear at the same time to have two different colours. This is not a proposition to be proved by argument; it is a first principle; if we attempt to conceive the contrary, we find it impossible.

strong

strong light was admitted, and drew a line on the paper dividing it into two parts, on of which was seen by the right eye, and the other by the left; but neither of them could be seen by both eyes together, the distance being about three feet. While looking steadily at the paper with my right eye, I applied a piece of stained glass to the left eye, when immediately a light tint of the colour, became sensibly spread over that side of the white paper which was seen by the right eye only. In making this experiment I found, that if dark stained glasses were used, the sensation of the eye to which they were applied was too weak to affect the strong sensation of white light on the other eye; but when I used a glass moderately stained, the diffusion of the light tint was very obvious.

THIS experiment appears to me equally with the former to afford a decisive proof that the sensation of one eye is affected by
or

or blended with that of the other eye; for how otherwise can we account for an object appearing coloured by the application of a stained glass to the eye by which that object cannot be seen.

EXPERIMENT III.

TAKE one of the tubes above-mentioned, and closing one eye apply it to the other, not close, but at the distance of three or four inches, and look at the wall or wainscoat, or at any plane surface of a light colour; and the object or surface, as seen through the tube, will appear of the same colour and brightness as that part seen on the outside of the tube. Next, bring the tube close to the eye, the other remaining closed, and the object seen through the tube will appear somewhat brighter than before; and this I conceive to be owing to the contrast with the blacked inside of the tube. Now, open the
other

other eye, and, looking at the surface or object with both eyes at the same time, the superior brightness of the part seen through the tube will become much more sensible. In this situation, the part of the surface seen through the tube is seen by both eyes, whereas the other part of it seen without the tube is seen only by one eye; and the remarkable superior brightness of this part seen through the tube must, as I conceive, be owing to the circumstance of its being seen by both eyes; that is, there is a double sensation of this part, and only a single sensation of the other part.

EXPERIMENT IV.

THE experiment I am now about to mention is best made by candle-light; and I have made use of one of the patent lamps as yielding a very strong light. It is a well-known fact, that if the eyes are suddenly closed,

closed, after having been for some time steadily directed to some bright object, a coloured spectrum will become perceptible. The nature of these spectra and the variations in colour to which they are subject, were, some time since, made the subject of a very ingenious investigation by Dr. Darwin. At present we have only to consider the general appearance independent of any particular colour.

LET the eyes be held steadily fixed on one of the above-mentioned lamps for a minute or two, after which, on suddenly closing them, a coloured spectrum will be seen. If any doubt should be entertained whether or not the two eyes are equally affected, in this case it may be clearly ascertained by looking with one alternately, the other being closed, at a sheet of white paper, when in either case a dark spot or spectrum will appear on the face of it.

I MEN-

I MENTION this circumstance merely to remove any doubt of each eye being equally affected ; but our experiment requires the eyes to be closed, when a single coloured spot or spectrum will become plainly perceptible. I request the reader's particular attention to the circumstances of this experiment: the spectrum appears single, and no forced distortion of either eye or of both at the same time can affect the unity of the appearance. But what is this appearance? it is merely a matter of sensation, the central part of each eye is strongly affected by the late impression of the light on it. Here is no external object seen or imagined, and consequently nothing respecting direction from the eye or external place can be concerned in this experiment; the whole relates to sensation; but as each eye is equally affected, the sensation must be united, otherwise the spectra would appear distinct; we have not even a consciousness of both eyes being concerned, and the method above-mentioned is necessary to

de-

determine whether one eye only, or both are affected.

If the eyes should be directed to some distant object, and the lamp should be placed before them, at the distance of about three feet, the projections of the lamp will be found on dissimilar points of the retinae, and two distinct spectra will be perceptible.

THE foregoing experiments, taken collectively, appear to me fully sufficient to establish the fact, that an impression or sensation made on a certain point of one retina is united, by some original law of the constitution, with the impression or sensation made on a certain corresponding point of the other retina.

THE intermediate colour perceived, when glasses differently stained are applied to the

two

two eyes, can only be accounted for, by admitting such an union of the sensation. Over each eye are diffused rays, exciting some colour, which, so long as both eyes remain open, is not perceptible; the colour being some intermediate tint; but on closing either eye, some colour different from this immediately becomes visible, without any alteration taking place in the eye by which such colour is seen. I can conceive nothing more conclusive. But from this fact if admitted, the single appearance of all objects naturally results.

THE appropriate sensation of the optic nerve is colour. In the last experiment of the spectrum, there is no external object visible or tangible immediately concerned, nor any rays of light in present action; the spectrum is a durable impression caused by the strong light lately seen; but this impression is made manifest by the perception of some colour, and this being excited,

the perception of extension follows as a natural consequence ; the spectrum itself is an extended and figured object.

WHEN there are two similar projections, one on each retina and on that point of the retinae where the optic axes terminate, or, according to the common notion, when we look at an object, the sensation is united precisely as in the case of the spectrum ; when these projections are of dissimilar objects the two will appear mingled together in a confused manner *. But it is clear from the
 expe-

* WHEN experiments have been made for seeing two differently-coloured objects united, by placing them one in the axis of each eye, the result has generally been, that at one time one only was seen, at another time the other, and at intervals the two have appeared confusedly united. But we should recollect, that in this experiment it is necessary, in order to bring the objects on those points of the retina where the optic axes terminate, that the state of the eyes, or at least of one of them, should be adjusted for some distance different from that of the object ; and if, as has been supposed, and as I believe is true, there is a change of the refractive state of the eye with every change of distance in the object, it must follow,

experiment of the spectrum, that neither direction from the eye, nor external place, nor position, have any concern in causing the unity of the appearance; these are merely relative and secondary notions; visible extension is a necessary adjunct or concomitant of colour, and the union of the sensation is in fact the union of the extension, with its modifications of figure, position, &c.

HOWEVER convincing this solution of the question concerning single vision may be to my own mind, I conceive it to be very probable that it may not appear equally so to others. But if it should not be admitted, it must, I think, be allowed, that we have no other more satisfactory, and that the

follow, that the sensation of one or both eyes in this experiment must be imperfect, because the refractive state of the eye cannot be adapted to the distance of the object seen; and to this cause we are probably to attribute the uncertainty and irregularity of this experiment; the sensation of one eye prevailing at one time, at another time that of the other.

question still lies open to future research ; and I should hope that what has now been said, may at least have the effect of promoting further investigation, and of suggesting other experiments which may lead to a more perfect decision.

It was at first my intention to have considered some other circumstances relating to vision, particularly respecting visible position as an original suggestion ; but I fear that the reader may by this time be tired of the subject, and I shall proceed no further at present,



THE END,

Fig. 1

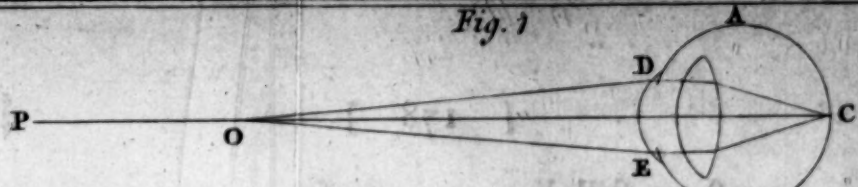


Fig. 7

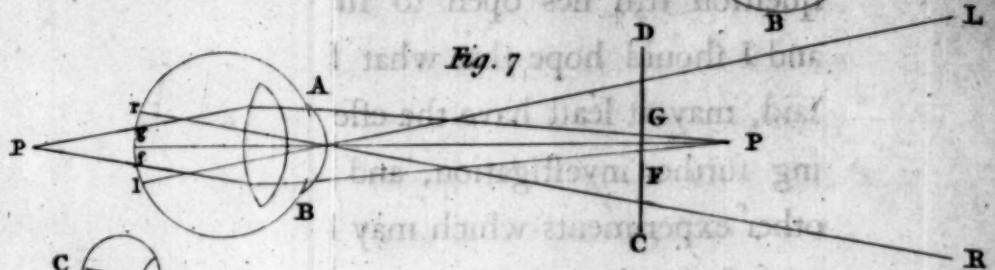


Fig. 2

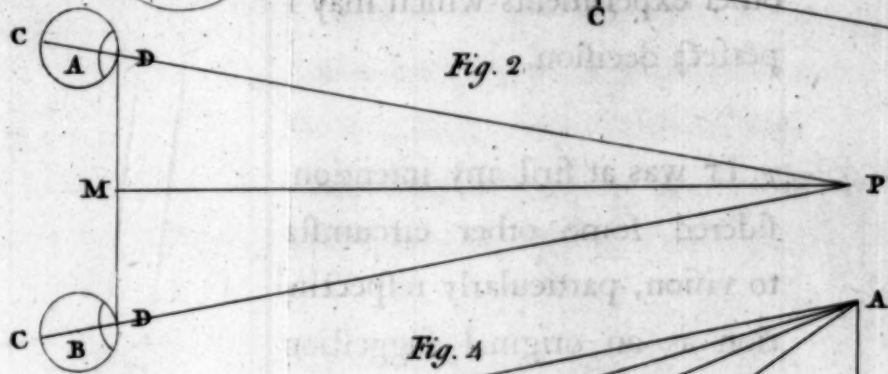


Fig. 4

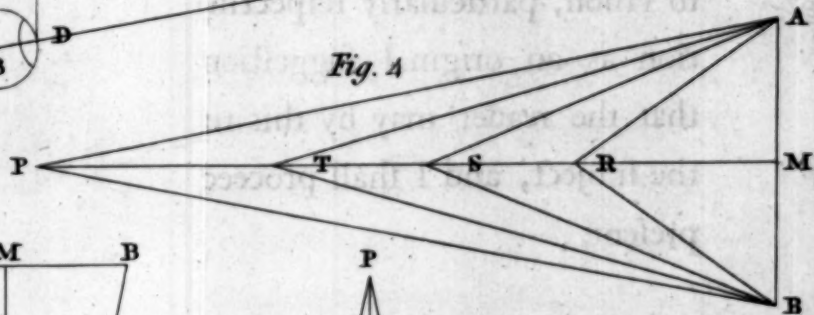


Fig. 6

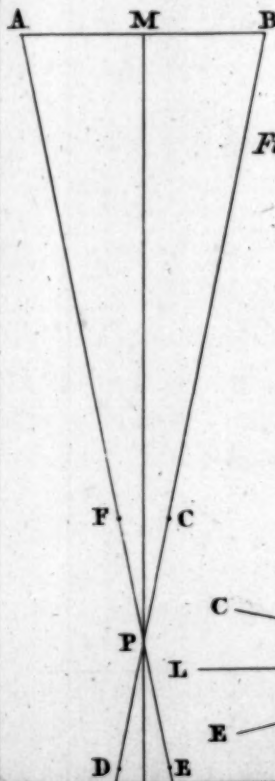


Fig. 5

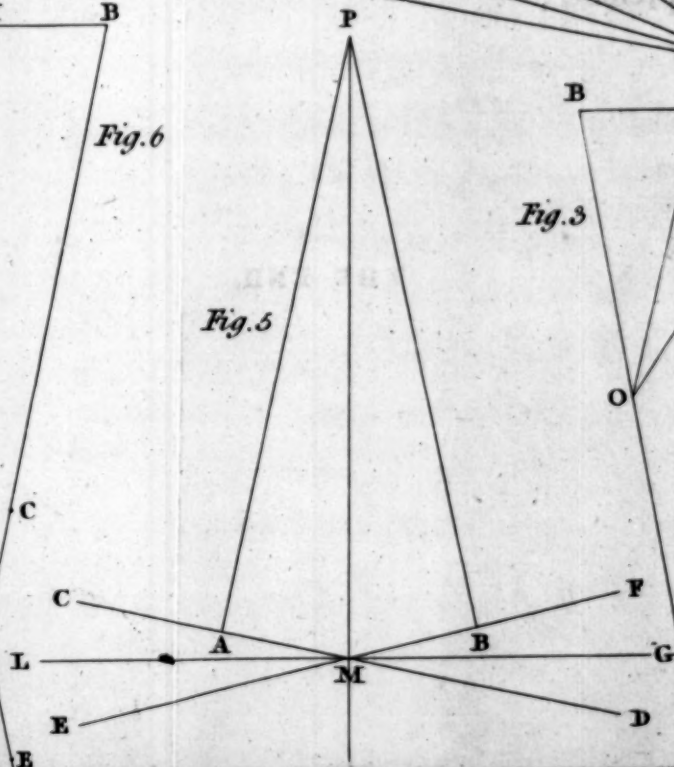
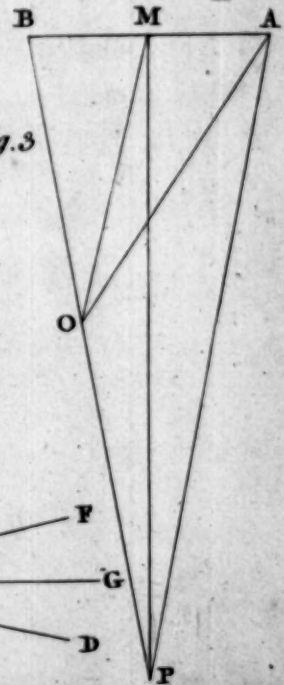


Fig. 3





The Reader is desired to correct the following Errors.

- Page 32, line 10 from the top, for *cube* read "sphere."
— 68, — 7 from bottom, for *objects* read "object."
— 91, — 12 from top, for *cause* read "consequence."
— 101, — 12 from top, for *object* read "objects."

THE TRINITY LUTHERAN CHURCH

1950-1951
1951-1952
1952-1953
1953-1954
1954-1955



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 present

OPERATIONS

SECTION 1

The first section of the report deals with the general situation of the company and the results of the operations during the year. It is divided into two parts, the first of which deals with the general situation and the second with the results of the operations.

The second section of the report deals with the results of the operations during the year. It is divided into two parts, the first of which deals with the general situation and the second with the results of the operations.